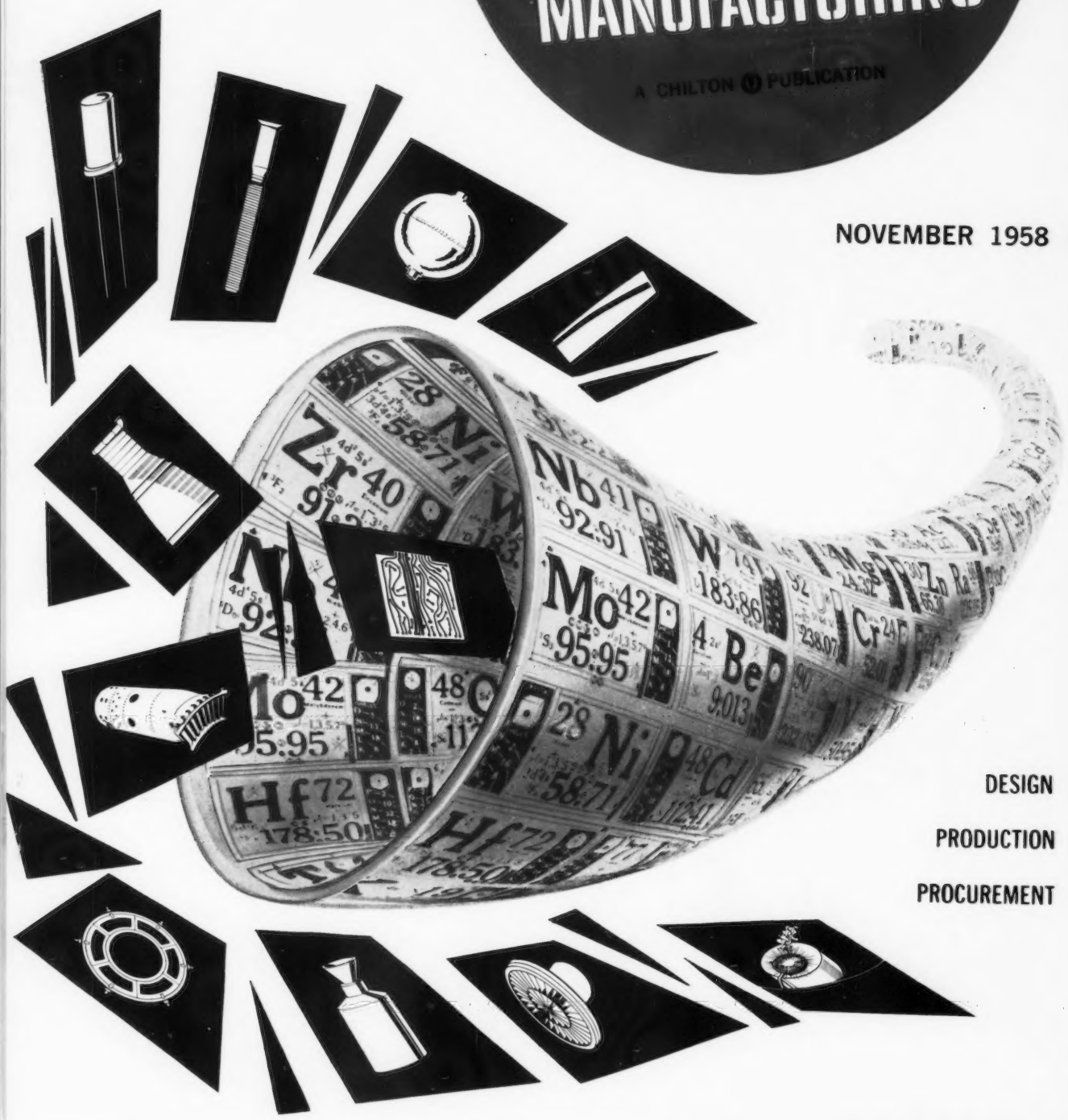
AIRCRAFT AND MISSILES MANUFACTURING

A CHILTON PUBLICATION

NOVEMBER 1958



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PRODUCTION

PROCUREMENT

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	Old Method	New Machine
Annual Prod. Cost—Bodies	$53,004	$14,464
Annual Prod. Cost—Housings	18,124	4,917
Annual Prod. Cost—Carriers	3,276	1,404
Annual Prod. Cost—Plates	1,200	630
Total Cost per Year, all parts	$75,604	$21,415
Annual Saving for New Machine		$54,189
Total Purchase Price		$24,967
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The *New* A-MP "24-20" Terminal and Connectors are designed expressly to resist *vibration, shock and similar stresses* encountered in wire applications in every industry. They retain all of the excellent features of the A-MP Pre-Insulated Diamond Grip line, with special emphasis on the need for weight and space savings so important in today's equipment design.

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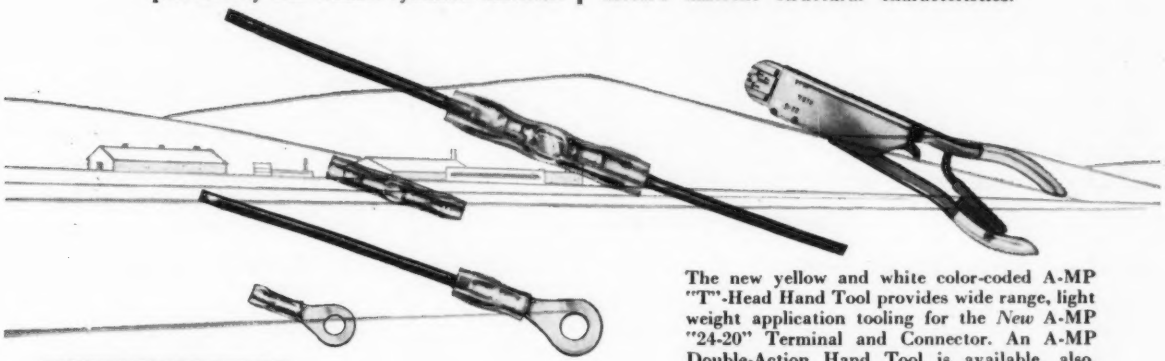

The new yellow and white color-coded A-MP "T"-Head Hand Tool provides wide range, light weight application tooling for the *New* A-MP "24-20" Terminal and Connector. An A-MP Double-Action Hand Tool is available, also. Both tools feature the A-MP Certi-Crimp® Control . . . for positive crimping of the terminal to the wire.

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A CHILTON PUBLICATION

THE COVER STORY

Much fruitless effort was spent by ancient alchemists to convert base metals into gold. Little did it occur to them that an abundance of gold would only serve to reduce its value. Had they directed more effort to develop the more-plentiful and useful metals, man's lot would have perhaps improved earlier. The recently-unlocked cornucopia of elements is just beginning to yield its bounty. The materials for building the vehicles and the powerplants of the future are already taking shape within the depths of this horn of plenty.

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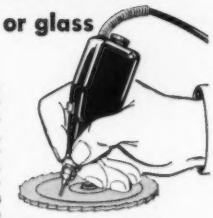

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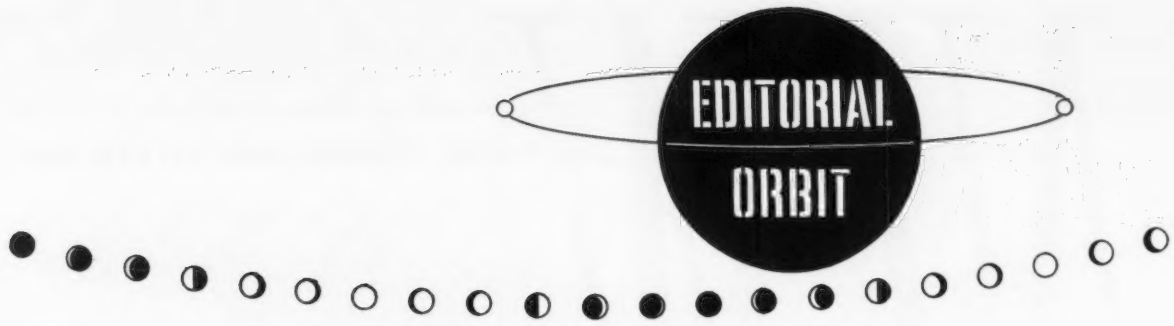


a crime—no coordination

It's amazing how many new materials are developed each year and still the cry is on for improvement. Many of the aircraft and missile manufacturers are working toward a common goal, yet using a variety of materials and processes to achieve it. This seems to us a very healthy condition.

But, when this free enterprise system exists within the plant itself, *there are problems.* You've seen it happen so often. When the design engineers are evaluating a new material, production knows nothing about it. The material is finally incorporated into a design and then the fun begins. The production boys take a look at the new material and wonder just how they're supposed to work with it. Nobody has ever told them to research the material. And, sometimes, it works the other way. Production engineers are often looking for some material that will do a better job. One that will machine better, hold closer tolerances or cut costs. In any case an immediate road block is thrown up. Design engineers want to do it their way or the production engineers want it their way. Take your choice.

Some companies are earnestly trying to correct this situation. Design engineers, and production engineers, as well as procurement men work together as a manufacturing team to evaluate new and existing programs. In these organizations, it's no longer up to one man to decide what is going into a new weapon system.

Many firms, however, still work that old backward way. If we don't remove the stumbling blocks, some serious financial problems might ensue.

For example, let's take the recent talk by E. R. Quesada, Special Assistant to the President and Chairman of the Airways Modernization Board. He announced, that contractors should be rewarded if they meet a program successfully, but, on the other hand, those who do not should be severely penalized.

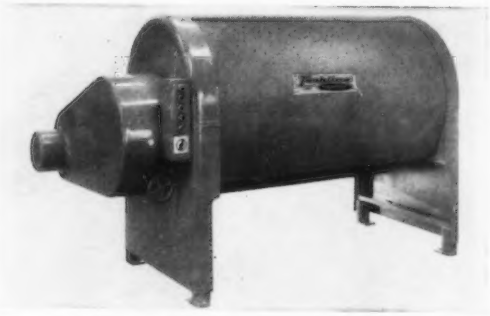
Take your own experience, certain contractors consistently meet the schedule, others never do. One major answer is this lack of design and production integration. There are too many cases on record about these factions fighting each other.

It's about time we use the manufacturing team approach. Most of us within the industry are getting sick and tired of production blaming design and design blaming production when product schedules aren't met.

Editor

NEW

NEW TECHLINE DIVISION IS



TECHLINE BARREL FINISHING EQUIPMENT includes a complete line of single and multiple-compartment machines. Because of their exclusive "modular" design, they are unusually economical, and available in almost endless combinations of size and capacity to meet all production requirements.

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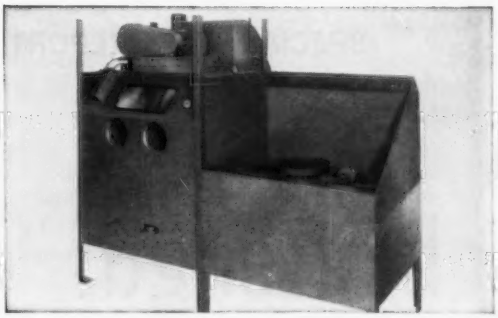

TECHLINE WET BLASTING MACHINES add the new "modular" concept of design to the famous Wheelabrator Liquamatte features, achieving new standards of economy and performance for wet blast precision cleaning and finishing. Standard units are available in a wide range of sizes and capacities.

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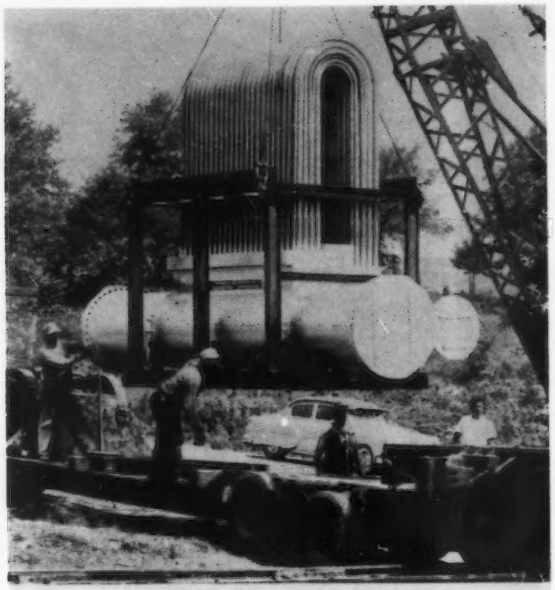
AIRCRAFT AND MISSILES MANUFACTURING

SPECIAL STAFF REPORT

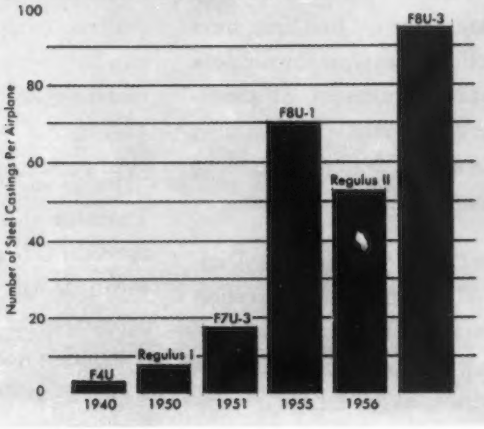
high-strength steel

use of steel in aircraft and missiles grows; no wonder metal–special steels do special jobs, semi-austenitic PH and 5 percent chrome hot-work are dominant newcomers



Heat exchanger for aircraft turbine testing contains six miles of 1½-in. O.D. x 16-gage, type 321 stainless tubing (Carpenter).

Use of castings by Chance Vought in aircraft and missiles indicates growing trend.



Aircraft and missiles are complicated vehicles. The wide range of operational environments and conditions they undergo makes material requirements for these vehicles likewise complicated. What may be the best combination of properties in one application, may be far from the best in another.

There are in existence, numerous data sheets and strength-to-weight curves which indicate the superiority of one metal over another. In many instances favorable results are obtained in graph form by using only those times and temperatures which favor the desired metal. This fact points out that there is no single perfect material for all aircraft and missile applications. Each application has its own requirements, each material has its own assets.

Strength-to-weight ratio, as a function of time and temperature is a universal evaluation criterion; ultimate tensile strength, yield strength, resistance to creep and corrosion, and fabricability are other major considerations.

Maximum service temperature for aluminum alloys is generally conceded to be about 350°F, that for magnesium alloys is slightly higher, titanium alloys and the more common stainless steels are best in the 350 to 600°F range; stainless and tool steels are used to

1000°F; super alloys and exotic metals are best for temperatures above 1000°F.

The Role of High-Strength Steel

This fact is undeniable: the search for new airframe and powerplant materials is on, the search is prompted by aerodynamic heating problems ("thermal thicket") and propulsion-source heating problems. Steels possess the happy combination of good strength and familiar fabricability characteristics. Such advantages are attractive to designers considering materials for current and immediately foreseeable generations of air and space vehicles. As a result, the tailoring of steels to these requirements has been accelerated and their desirability for specific applications has thus been enhanced.

The major classes of steel which show promise are;

- Precipitation-hardenable semi-austenitic steels.
- Hot-work tool steels.
- Martensitic steels.
- Low-alloy hardenable steels.
- Cold-rolled stainless steels.
- Precipitation - hardenable austenitic steels.

Precipitation-Hardenable Semi-Austenitic Steels

Of the newer steels, this group is rapidly becoming the work horse of the industry. This is because it combines the higher strength obtainable by martensitic transformation with "stainlessness" and ease of fabrication.

Many consumers are beginning to accumulate considerable experience in the use of this group for regular production of aircraft components. Boeing has used Armco's 17-7PH for seven years and Allegheny Ludlum's AM-350 for three years (forged tank fittings).

North American uses this class in supporting-structures for fuselages, interior frames, longerons, and stiffeners. Lockheed uses it in both room-temperature and elevated-temperature applications. Northrop and Douglas use it for a variety of applications in the manufacture of aircraft and missiles, from oxygen bottles to barstock for bolts. Convair uses it as skin and as integral tankage in ICBMs, and in brazed honeycomb in the B-58. Boeing uses it as tankage on their ramjet missile, the Bomarc.

Aerojet, Lockheed, Rohr, and Solar make extensive use of precipitation-hardenable semi-austenitic steels for the fabrication of such components as inlet guide vanes and honeycomb panels.

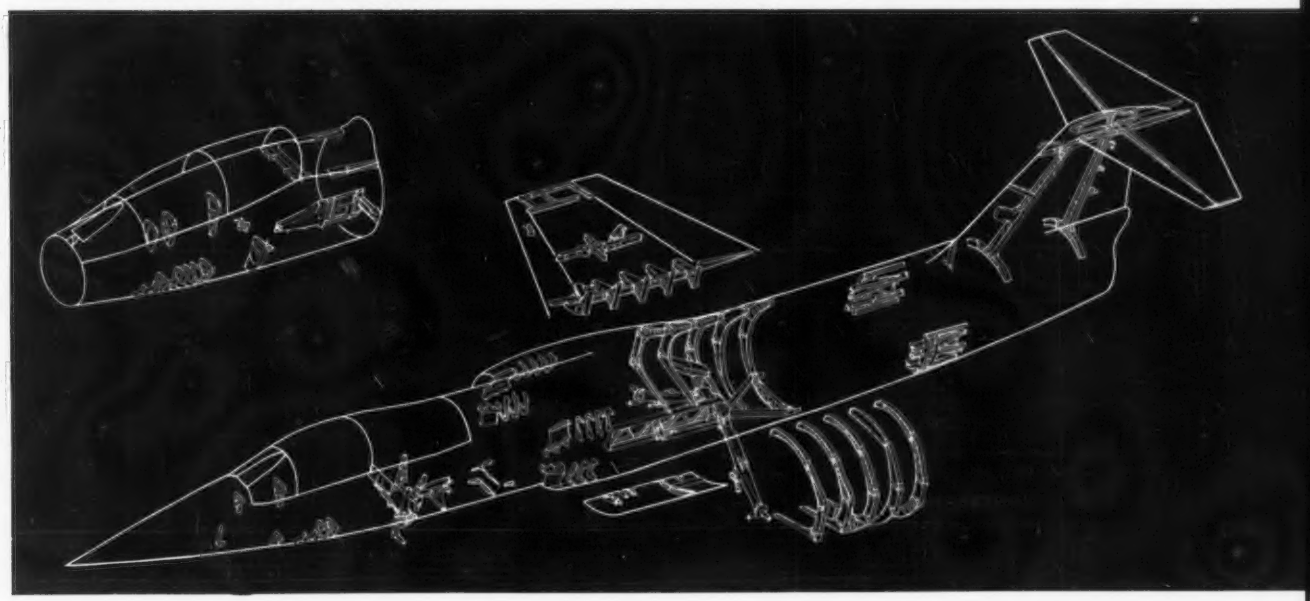
Numerous studies and development programs are being pursued by Convair, Lockheed, North American, Boeing, Rohr, and Ryan to investigate and improve dimpling properties, weldability, tensile properties, crack propagation, formability, and heat treating.

Hot-Work Tool Steels

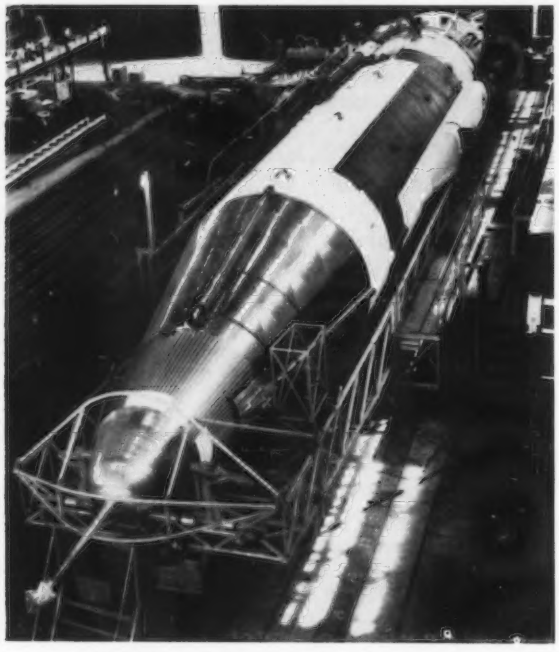
The important advantage of hot-work tool steel over more conventional high-strength steel is that it resists softening at high temperature to a much greater degree. This is because it can be tempered at much higher temperatures of the same level of strength. Its resistance to softening and extremely high strengths attainable make hot-work tool steel attractive for a variety of aircraft and missile applications.

Beside the advantage of high temperature strength at relatively low cost, other advantages are (1) being air hardened, they do not distort as

Extent of forgings (aluminum and steel) used in current fighters is typified in drawing of Lockheed F-104 Starfighter.

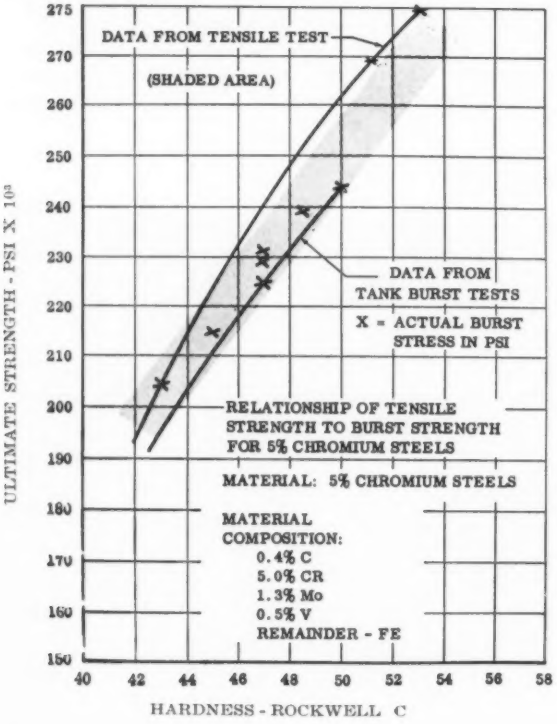


high-strength steel . . . continued



The Atlas, clad in gleaming stainless, awaits final inspection in Convair's San Diego plant; this missile embodies parts from 1200 suppliers throughout 32 states.

Fig. 1. Burst pressures for rocket casings are predictable with five per cent chrome hot-work steels. Solar Aircraft has found correlation between uts and burst stress.



much in heat treatment; (2) offer better oxidation-resistance than low-alloy steels due to a higher chromium content; (3) provide satisfactory fusion welding characteristics; (4) are not notch sensitive (parts do not fail easily after being nicked or scratched); (5) can be spun, stretched, or formed in the soft condition.

Such prime manufacturers as Lockheed, Boeing, North American, Douglas, Convair, and Northrop see potential here and are currently experimenting with hot-work tool steels to evaluate their properties and gain experience in using them. In addition, such subcontractors as Ryan, Rohr, and Solar have programs of experimentation and development with these steels.

North American (Columbus) has actually been using hot-work steels in airframe production to effect a saving of weight for the Navy's new twin-jet attack bomber, the A3J. It is used for section stiffeners, canted bulkheads and as larger members in the landing gear assembly.

Solar reports that the air-hardening 5 per cent chrome hot-work tool steels which formerly bore the AISI designations H-11 and H-13 are considered the outstanding newcomers in high-strength steels. Of the presently-available sheet, bar-stock, and forgings that can be fabricated by conventional means, this class of materials has few if any peers.

Solar's experience with these steels has been in the fabrication of jato bottles, pressure vessels, and solid-propellant rocket-casings and missile fuselages. Figure 1 is of particular importance because it shows that Solar has been able to obtain theoretical burst pressures on tanks heat treated to very-high strength levels. It has been found that with other materials, notably precipitation hardening stainless, welded pressure-vessels fail far below theoretical burst-pressures.

In the construction of power plants for missiles, Aerojet-General also employs hot-work tool steel for pressure-vessel walls, as well as turbine buckets, and clevis and belt combinations.

Both Convair and Lockheed believe that this class of steel will be useful in missiles designed for short life, i.e., in the order of two minutes.

Martensitic Stainless Steels

This class of steel has the advantage of a better oxidation and corrosion resistance than that of hot-work tool steel. The disadvantages in welding, machinability, embrittlement and warpage require considerable development work before its future as structural material can be assured.

Aerojet-General uses a considerable amount of this series in welded tanks for missile power plants. Boeing and Convair are both currently attempting to improve welding techniques and to solve heat treating problems.

Of the major new steels for aircraft and missile applications, this class presently seems to attract least interest.

Low-Alloy Hardenable Steels

Low-alloy hardenable steels provide exceptionally-high yield strength for high-temperature applications. They have the advantage of low cost. However, they retain the disadvantages of martensitic types, i.e., are difficult to weld, machine, and are prone to embrittlement.

These alloys find most extensive use in drum, disk, and segmented disc-brakes where high rates of heat input are involved in stopping the aircraft. They are also used in jet engines as sheet and rolled rings for outer combustion-chambers, tail-cone assemblies, and for compressor wheels and blading where temperatures reach 900°F. The higher vanadium-content alloys are employed in turbine rotors and missile components in which high skin-temperatures are experienced for short periods.

The standard low-alloy hardenable steels are in general used as structural components for aircraft. The vanadium modified (4330, 4335, 4340) are used for airframe members and for landing gear components. Sheets and tubing of these materials are used to a considerable extent (i.e., exhaust systems on engines).

Hot-bolding steels such as Timken 17-22A types are used as bar stock, forgings, and sheet. Typical applications are jet engine compressor cases and cylinders which actuate the nozzles in afterburners.

One school of designers has persisted in the approach that these materials, namely 4340, could continue to serve the aircraft and missile needs by reducing the tempering temperature and hence increasing the strength. Lockheed has been conspicuous among the major airframe manufacturers who have taken this view. Lockheed's approach some time back was to decrease the tempering range to 400 to 450°F, ultimate tensile strength was raised to 270,000 psi. This process skipped the so-called 500°F embrittlement tempering range. Lockheed was little concerned about the high hardness and questionable impact-test results, for they did not admit to any importance of this test in gaging the suitability of the steel for the purpose in view.

Lockheed uses 8630, 4130, 4140, 4340, and 8740-steel forgings, fittings machined from bar stock, and extrusions. 4130, 4330, 8630, and 410 steels are used in castings.

Crucible Steel Co. took an approach which resulted in an alloy called Hy-Tuf. Proper amounts of silicon added to the 0.40 per cent carbon steels had the effect of imparting resistance to tempering and displacing the embrittlement-range to the right on the tempering-temperature scale.

US Steel Corp. has evolved a low-alloy steel called Airsteel X-200. It is said to be as workable as 4340, and air-hardenable to 280,000 psi tensile strength. The fabricability of this class will enhance its future.

Cold-Rolled Stainless Steels

Cold-rolled stainless steels for aircraft represent a sizeable percentage of the stainless steel market. They possess the advantage of simplicity in manufacture, where little or no forming is required, but where high strength and resistance to corrosion is necessary. Due to their strength-retention qualities, these steels are frequently used in applications where moderate temperatures are attained. They are of particular interest for missile construction.

Convair uses cold-rolled stainless in missile application. Aerojet uses them for a variety of components, e.g., outer liners for thrust chambers. Other prime manufacturers use these steels for applications to 900°F.

Precipitation-Hardenable Austenitic Steels

At service temperatures above 1000°F, this class of steel demonstrates its superiority. Beyond their applicability for high-temperature service, these steels find use where their combination of excellent corrosion-resistance and moderate strength are required, or where their strength and toughness at sub-zero temperatures are advantageous. The fact that they are nonmagnetic also makes them useful for specific applications.

A number of consumers make limited use of these steels, several are Aerojet, Ryan and Rohr.

Sheet

In designing the Hustler, Convair was not able to meet weight limitations using conventional structural designs. The solution was the extensive use of steel sandwich construction, both bonded and brazed. Since some critical areas of the aircraft might reach or exceed 300°F at maximum performance, brazed structures were used throughout the elevon, nacelle struts, and on portions of the wing and engine nacelles. Total area of brazed construction is approximately 870 sq ft; a small percentage of total airframe area, but an indication of the unmistakable trend toward high-strength steel.

Atlas ICBM is practically a steel balloon. Tanks comprising almost the entire length of the missile are of thin gauge stainless steels. Except for the warhead, the entire protective skin of the Atlas is precipitation-hardened stainless.

The B-70 chemically fueled bomber, being developed to replace the present B-52, uses stainless steel in structural framing members, wing

and body skins, and near the hot end of the engine compressor.

It is reported that steel will be employed in about the same areas on the new F-108. It will include sheets for skin, foil for honeycomb, forgings and some rolled structural-supports.

The first manned space-ship, the X-15 (approximately 3600 mph), has an Inconel-X outer skin, and an inner skin of semi-austenitic precipitation-hardened stainless. Fuel tanks are allegedly stainless.

Paralleling the increase in airframe operating-temperatures has been a growing trend in aircraft gas turbines toward higher compression-ratios and "hotter" fuels, with a resultant increase in combustion temperature and turbine-inlet temperature. The temperature range of 300° to 1200°F to be expected on airframe sections is also foreseeable for the compressor stages of gas turbines. For this reason, many manufacturers use high-strength steel sheet to house the engine.

Forging

The vital engineering feature of forgings is that the manufacturer has a superior section, free of notches inherent to fabricated assemblies, with high and uniform properties throughout the cross section. Steel forgings are currently being used in landing gears, wing-attachment fittings, main spars and tail assemblies.

Aircraft like the F-104 and F-105 are notable examples of the uses of forgings. F-105 is "built around" a steel forging in the center section fuselage. This forging is used as a fuselage former and structural member, and as the primary member to effect the wing jointure.

Producibility Engineers have shown that the heavy-press program makes possible the design of airframes almost completely around forgings. Many of those used today are aluminum forgings, but as temperatures increase, so will the use of steel forgings.

In the Lockheed F-104, steel forgings are used in the front beam of the vertical stabilizer, and in the main fuselage frame.

Crusader series uses some steel forgings in the landing gear, as do most other aircraft. B-47 in particular uses main landing gear columns forged from steel in closed dies. These forgings are 12 in. diam by 1½ in. wall thickness.

Castings

As the performance of aircraft is extended, the space available for structural components is diminished. Thinner wing sections and propulsion and control requirements leave practically no space for structural fittings in the fuselage. This results in parts of extreme complexity which require maximum strength. The logical solution in many instances is the use of close-tolerance steel castings.

Chance Vought Aircraft is a leading user of steel castings, employing the following in the manufacture of aircraft and missiles:

- 72 castings, including 21 ground handling items, are used in the F8U Crusader. This leaves 51 airframe castings.
- 57 steel castings are used in the Regulus II missile, of which five are ground handling items and 4 are expendable launching parts. Many are in the "larger than investment" category. The launching frame casting is made of 4330, weighs 285 lb and has a minimum tensile strength of 150,000 psi.
- 95 steel castings, including ground handling items, are predicted for the F8U-3. This does not include any of the large future-design castings.

Tubing

With the advent of corrosive missile fuels and aircraft hydraulic fuels, stainless steel tubing has found considerable application. In some instances rigid tubing is used and in other instances the stainless is used as a braided protecting agent for tubing with Teflon or other inert core. Rigid tubing is also used in tremendous quantities in heat exchangers employed in the heat treating of aircraft and missile components.

Hustler uses Oronite hydraulic fluid which is corrosive, and hence stainless tubing is used. Fairchild's new F-27 is devoid of hydraulics but uses 18-8 steel tubing in the pneumatic system.

The peculiar design arrangement of the Atlas and Thor vernier rocket engines made rigid stainless plumbing the only logical solution. Practically every ballistic missile uses stainless braided Teflon hose, or an equivalent in the highly-corrosive oxidizing system.

Thermal Research and Engineering Corp., Conshohocken, Pa., recently built a heat exchanger that contained six miles of 1½-in. of 321 welded stainless tubing stabilized with titanium.

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high-temperature brazing

key to fast, quality production of advanced components

by **John V. Long**, director of research
George D. Cremer, senior staff engineer
Solar Aircraft Co.

Braze joining of metal parts is rapidly becoming a major manufacturing process. The inherent advantages of brazed joints are now widely appreciated from a practical as well as a fundamental and theoretical standpoint. This progress has been stimulated by a multitude of applications in the jet aircraft and missile fields. Need for high strength-to-weight ratio structures and the development of certain high temperature brazing alloys have largely been responsible for these advances.

The trend in aircraft engine, airframe, and missile structures is unmistakably toward sheet metal assemblies. In order to economically produce these temperature-resistant, lightweight, strong structures, brazing will assume new responsibilities. A particularly fertile field is known as high temperature corrosion resistant brazing. Brazed components can be fabricated today that will withstand afterburner jet blast at temperatures of 2000°F and above.

Design - Engineering, Research and Production Departments, at Solar Aircraft Co. have succeeded, through coordinated effort, in building up a noteworthy series of production brazing accomplishments. They have demonstrated that brazing processes are destined to play an increasingly important manufacturing roles in the history of aviation.

A vital ingredient in the modern evolution of applied brazing is production brazing facilities. This article describes one company's experience in the selection and development of furnace heating equipment. By presenting a variety of applications, the broad implications of braze joining methods should be obvious.

Solar's Entree

First large scale use of brazing at Solar-San Diego was in the Tool Grinding Shop. Here cemented carbide tools were ground and repaired. Methods Department had determined that for efficiency and economy, Solar should make their own tools.

Tungsten carbide blanks were to be silver brazed onto machined steel shanks. Considerations for heating of components for brazing included: oxy-acetylene torch, electric furnace, gas furnace, induction and direct resistance. The opposed Selas type gas burner arrangement, provided the answer. Approximately one-hundred thousand carbide tipped tools have since been silver brazed on this simple, flexible equipment.

Natural gas-air mixture is used. Time to preheat and braze is roughly 1 to 2 min. At a brazing temperature of approximately 1350°F, the operator manually aligns the tool-bit with a rod. This also squeezes out excess flux and braze. The brazed tool is then removed, again aligned, and pressure maintained on the carbide bit until it has cooled below a red heat.

A major advantage of this easy-to-operate and inexpensive furnace equipment, is that a wide variety of sizes and shapes to tools can be accommodated.

Manifold Sections

Internal combustion engine exhaust manifolds and intake manifolds for aircraft must be lightweight and strong. Joining of flanges to the sheet metal ducting has generally been done by fusion welding or resistance welding methods. Nine years ago Solar installed a production line to silver braze and brass braze certain intake

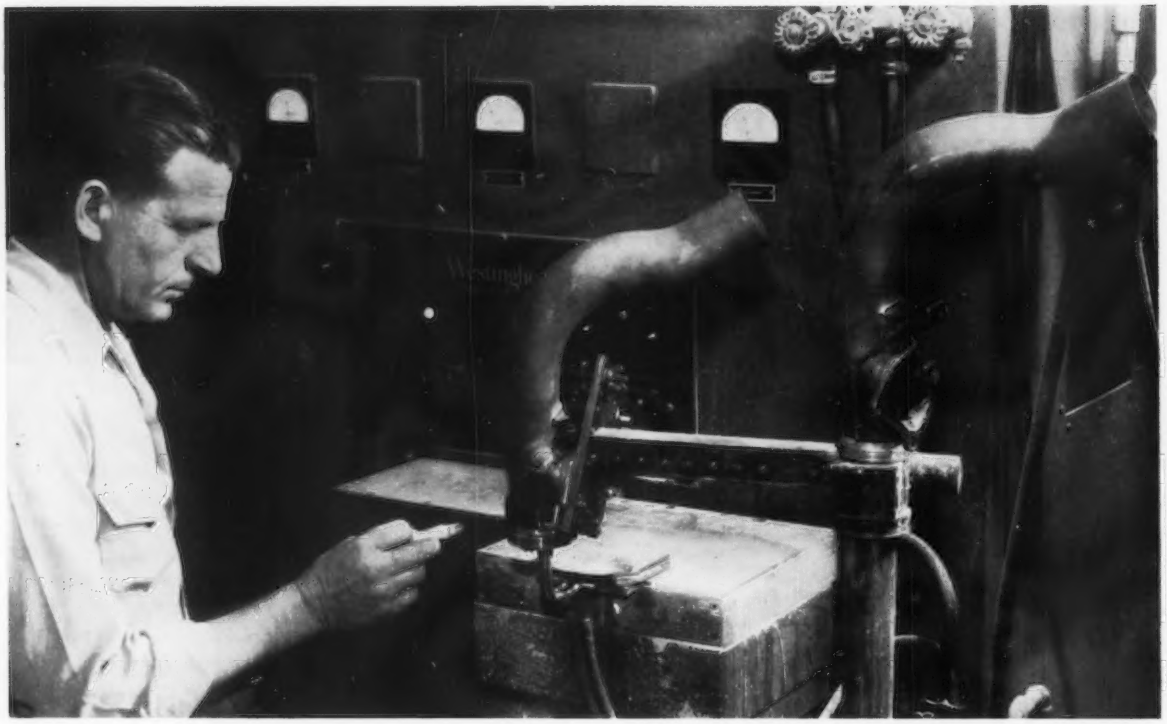

Fig. 1. Base metals of 1020 and 4130 steel are silver brazed in some intake manifold applications. BAg-1 alloy is used in this case.

high-temperature brazing...

continued

Fig. 2. Exhaust manifolds are brazed with high temperature nickel base alloys. Brazing is automatically controlled at 2050° F for 1 min.

manifold sections. Base metals were SAE 1020 and 4130. The accompanying illustration (Fig. 1.) shows such a silver brazing operation in progress. A braze wire preform was used with supplementary filler added. Westinghouse vacuum tube induction heating sets and Tocco motor generator induction units have been used on this job. Outstanding production records were achieved on these intake manifold flange-to-duct assemblies. Over 1 million brazed joints manufactured attest to the applicability of the induction brazing technique employed.

As in most aircraft component manufacture, X-ray quality joints were specified.

Corrosion Resistant Brazing

Success and manufacturing know-how were gained from induction brazing of low alloy steel intake manifolds. This set the stage for the next major step: high temperature corrosion resistant brazing.

High temperature corrosion resistant brazing is a metallurgical joining process in whch a corrosion-resistant molten filler metal is used. Melting point is in excess of 1600°F but below that of the base metal. Diffusion between filler metal and base metal must occur.

Fig. 2 shows a high temperature brazed manifold joint in the process of being made.

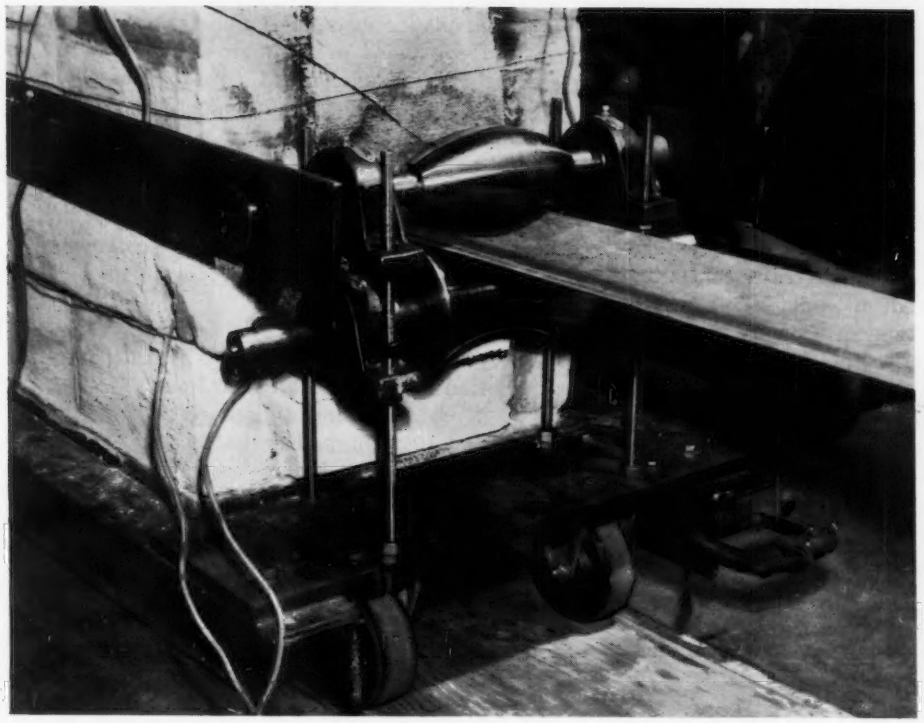

Fig. 4. Stator blades are single piece, folded sheet-metal with a resistance welded closure at trailing edge. Traveling furnace is used in operation.

An internal type induction coil is used to insure even heating and easy accessibility. Nickel base, corrosion resistant Solabraze alloy powder is positioned by an adhesive on the lip of the Type 347 cast flange. A special refractory coating-flux protects the joint extremities and braze alloy during the one minute heatup period.

Both Westinghouse vacuum tube induction and Tocco motor generator inducting heating units have been used in production. In each instance a program controller with optical temperature heat eye imposed a one minute soak at 2025 to 2050°F, followed by a reduced power cool-off in one-half minute to 1850°F, then rapid air cool.

Inspection of such high temperature brazed manifold joints is two-fold. Visual, by examination for continuous braze fillet formation at the lower end of the $\frac{3}{8}$ in. lap joint. Radiography is then used to provide complete joint quality records.

Pusher Furnace

Another facility that finds use in Solar's development of brazed assemblies is a 12 in. diam hand-pusher type resistance element tube furnace, manufactured by the Pacific Scientific Co. It has a vestibule purge chamber, 36 in. heat zone, and a 48 in. water jacketed cooling chamber. Gate valves partitioning the heat zone and close

Fig. 3. In honeycomb panel layup, stainless steel core ribbons are tacked to edge channel by means of silver-manganese alloy foil.

fitting doors at the tube ends serve to maintain a high purity gaseous atmosphere within the furnace.

A furnace of this type is a prerequisite to a continuous mass production type brazing facility. Instead of "hand-pushing" trays containing components to be brazed, an endless belt, pusher system is used. This type of furnace was used in Solar's pioneering effort of sheet metal stator blade manufacture.

Honeycomb Panels

The advent of all-metal honeycomb sandwich structures for critical aircraft applications has already upset many conventional manufacturing concepts. The one pictured in Fig. 3 is a resistance braze-weld operation in which 0.001 in. stainless steel honeycomb core foils are "tacked" by means of an intermediate 0.002 in. silver manganese or sterling silver braze metal strip to a 0.032 in. "U" channel.

A condenser discharge welding unit supplies high surge current to the small copper tipped hand piece. Ground connection is through the core and channel being assembled. Each cell must be "brazed-welded" a minimum of six spots to the channel-frame so that all core-to-frame joints will be sound during a subsequent furnace brazing operation. This insures maximum strength-weight properties of the brazed honeycomb sandwich panel.

When thin metal facings and braze metal are added to the honeycomb structure components, the completed assembly is ready for furnace brazing.

Two 2200°F, 35 ft giant elevator furnaces built by the Pacific Scientific Co. are currently in production for this operation at Solar.

Working chamber dimensions are 8 ft diameter by 10 ft high. Kanthal heating elements cover the wall and door areas. The door being independent of the work charge during loading and unloading, permits uniform, rapid heating and cooling of the work charge. Each door also contains a 50 kw heater which insures fast, uniform heat control in the furnace chamber.

The larger power furnace, (V-2), is rated at 600 kw. Elevator capacity is 2 tons. One unit has a circulating fan which permits precision heat treating operations to be carried out at intermediate and lower temperature.

Fig. 5. Stator blades are brazed to engine shroud in type of induction heating generator shown. Silver braze alloy (AMS 4770) is flowed on at approximately 1300° F.

Fig. 6. Pacific pit-type furnaces are used to braze up to 12 complete stator assemblies simultaneously for small gas turbines. "Christmas tree" fixture in front of furnace houses assemblies during brazing. Completed assemblies are displayed on furnace ring.

A high purity flowing atmosphere, generally argon or hydrogen, is maintained throughout the brazing cycle. This insures "bright annealing" conditions which promotes free flow of the brazing alloy and results in a quality product.

Sandwich beams have been produced up to 12 ft in length. In this development, a small traveling furnace (Type T-2) measuring 1½ ft x 2 ft x 6 in. is utilized to progressively high temperature braze the sandwich assembly. By carefully controlling the relative motion of furnace and work piece, and time-temperature relationship, a brazed beam can be produced continuously.

Gas Turbine Guide Vanes

Silver brazing has been used with outstanding success in the manufacture of vane-shroud assemblies for aircraft gas turbine engines. Solar Aircraft Company's Des Moines and San Diego plants are major producers of such components.

AMS 4770, Easy-Flow type brazing alloys are employed for front compressor stator stages where operating temperatures are below about 400°F. AMS 4772 (54% Ag, 40% Cu, 5% Zn, 1% Ni) is used in certain higher temperature stages.

Hollow stator vanes are single piece, folded sheet metal with a resistance welded closure of the trailing edge, fabricated continuously as shown in Fig. 4. Vane ends or tabs extend through corresponding inner and outer slotted shrouds of jet engine casing. By accurately bending these tabs flat, a tight assembly suitable for brazing results.

Fig. 5 shows a single vane-end in the process of being silver brazed to the outer, slotted shroud. Preforms of braze metal foil obviate the necessity of hand feeding the alloy. Unbrazed joints painted with white flux are clearly visible at the left of the single turn high frequency induction heating coil. Each braze joint of this type requires approximately a two minute heating cycle.

Massive fixtures are used to securely position the entire stator assembly throughout the numerous localized brazing operations.

Complete Stator Assembly

Furnace brazing of small gas turbine stator assemblies is also being evaluated. A standard Pacific Scientific pit-type furnace, shown in Fig. 6, is employed in the silver brazing of stainless steel stators. Eight to twelve complete stators are braze-assembled in one furnace charge, each stator being supported on a "christmas tree" fixture as shown.

In order to minimize amount of flux required, protective atmospheres of argon, helium or "high nitrogen" have been used successfully. The furnace brazing method shows promise as a production means for the precision assembly of precision components. This method appears particularly attractive if nickel base brazes are employed with fluxless type brazing in purified hydrogen atmospheres.

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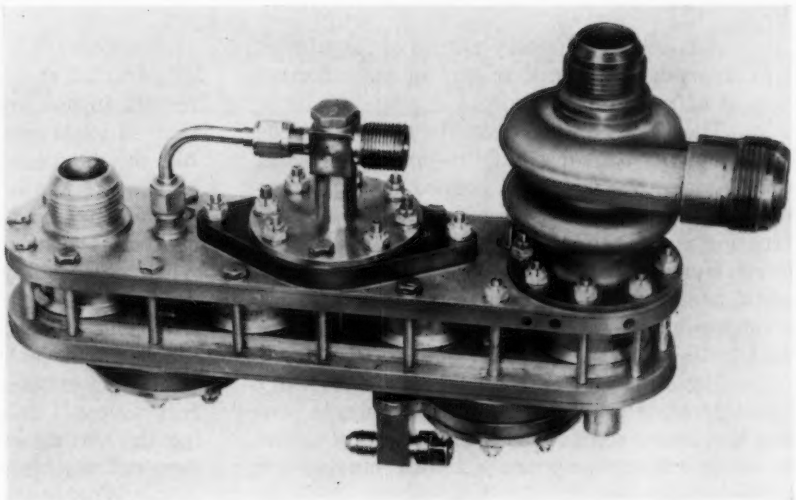

Typical of complicated components being braze assembled is this stainless steel control, which contains 110 brazed joints.

Mace is a tactical ground-to-ground missile that can be launched from mobile platform.

Mace wing-forging design

Tongue and groove jointure of two 7075-T6 forgings at fuselage center-line is used to mate right and left wing sections of Mace. Forging is 106.5 in. long, 5⅛ in. thick and 7 in. wide, and consists of two pieces.

precision-forged contour on two-piece 7075-T6 wing member reduces fabrication costs

by **S. J. Snyder**, tooling project engineer, The Martin Co.

A missile by the very nature of its mission is an expendable item. Economy of manufacture then, is of prime importance.

The result of producibility studies on the TM-76 Mace (tactical ground-to-ground) missile, was to make the wings of bonded metal honeycomb, since this offered the most economical construction method. Each wing panel extends 11.45 ft out from a 7075-T6 wing root forging. Individual panels are joined at the fuselage centerline by tongue and groove attach points in the forgings to effect the completed Mace wing.

Planning of the manufacture of the wing panels presented a real challenge, namely, to produce this major component as economically as the six other major components that comprise the missile.

Because of the sweep back and negative dihedral of the wing design, a twisted contour results in the area of the attachment forgings. Conventional processes would require that a part like this be machined on a Hydrotel with a great amount of handwork for finishing. Or, a special machine would be built to machine the difficult contour. Neither of these approaches was in line with the economy sought. Final decision was to forge each wing fitting in two pieces, with the emphasis of accuracy being placed on the contoured surfaces. With a two piece forging, having the proper contour, the thickness of the assembled forging could be maintained by simply slab milling the mating surfaces, thereby eliminating any involved machining on the contour.

Working in close cooperation with Alcoa

USAF TM-76 MARTIN MACE SPECIFICATIONS

NAME	MACE	RANGE	Over 650 mi
TYPE	Tactical Missile-Surface-to-Surface	MAX. ALTITUDE	Over 40,000 ft
		SPEED	Over 650 mph
SERVICE DESIGNATION	TM-76	PROPULSION	Allison J-33-A-41 turbo jet
LENGTH	44 ft		
DIAMETER	54 in.	THRUST	5200 lb
WINGSPAN	22.9 ft	BOOSTER ROCKET THRUST	approx. 100,000 lb
		GUIDANCE	ATRAN or Inertial

engineering personnel, Martin has found that forgings can be produced with a contour tolerance of ± 0.005 in./in.

To be sure acceptable close tolerance forgings are used in manufacturing, duplicate dial indicator type check fixtures were constructed. One is used by Alcoa and the other by Martin receiving inspection.

After acceptance by inspection the forging is sent to the machine shop where it is clamped in a cradle type mill fixture and the mating surfaces of each "half forging" are slab milled to finished size. This fixture is fitted with gage blocks for setting the milling cutter to the proper depth.

The forging is then placed in a multiple airfeed drill fixture where all the holes for joining the two halves are drilled and spotfaced simultaneously. The two halves are then bolted together and checked for contour to ± 0.010 in. The two halves bolted together constitute the wing root attachment fitting for one wing panel.

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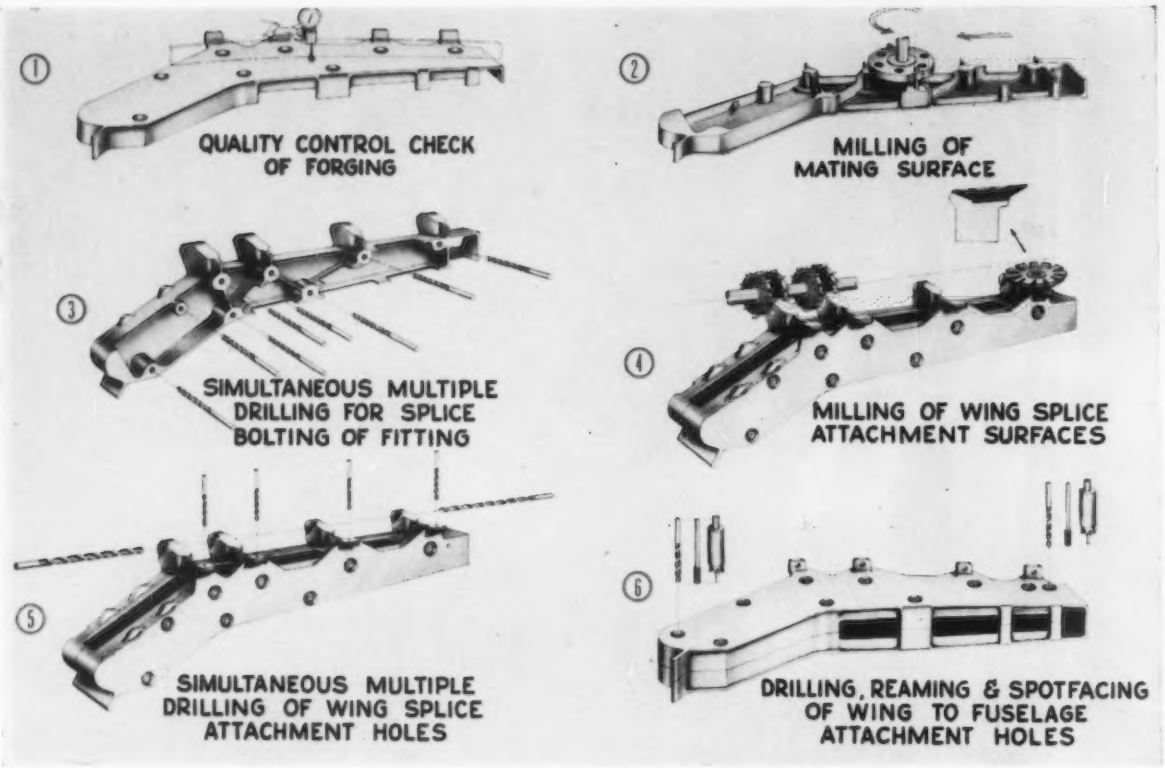
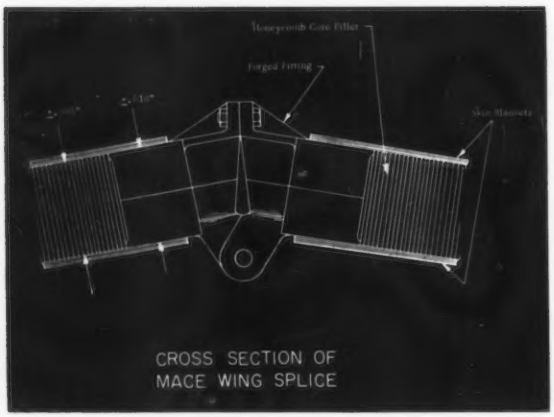


MANUFACTURING FLOW CHART
Sequence of Operations and How They Are Performed

Mace wing-forging design . . . continued



The tongue-and-groove surfaces which mate with the fitting of the opposite wing panel are then "gang" milled to final dimension.

The splice and hinge attaching holes which join the right and left hand fittings together, to form a completed wing assembly, are drilled simultaneously in a multiple airfeed drill fixture. The last operation is the drilling, reaming and spotfacing of holes for the wing to fuselage attaching bolts. When this is completed the fitting is cleaned, given a light sandblast, and the adhesive is applied which will join forging and contoured honeycomb sections to be bonded as an integral part of the wing panel.

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Two piece forging is shown in Airfeed drill fixture where holes are drilled that are used to join right and left wing sections.

Finished forgings are bonded into honeycomb wing panels. Wings can be mated to fuselage at Martin or shipped for field assembly.

CUT MAINTENANCE COST!

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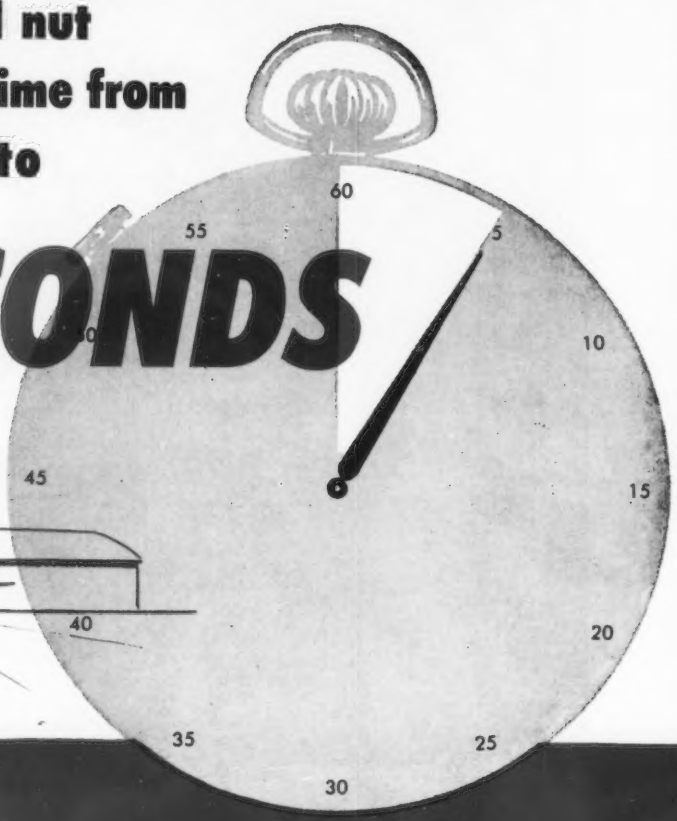

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Circle 137 on Inquiry Card, page 81

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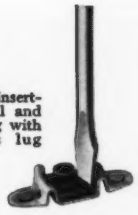
1

Insert removal tool, with downward pressure, between nut and shell, as shown. Lean tool against nut barrel to insure engagement.

2

Maintain downward pressure. Nut will snap out easily with a simple prying motion.



3

Install new nut by inserting one lug in shell and striking opposite lug with screwdriver. This lug snaps into place.

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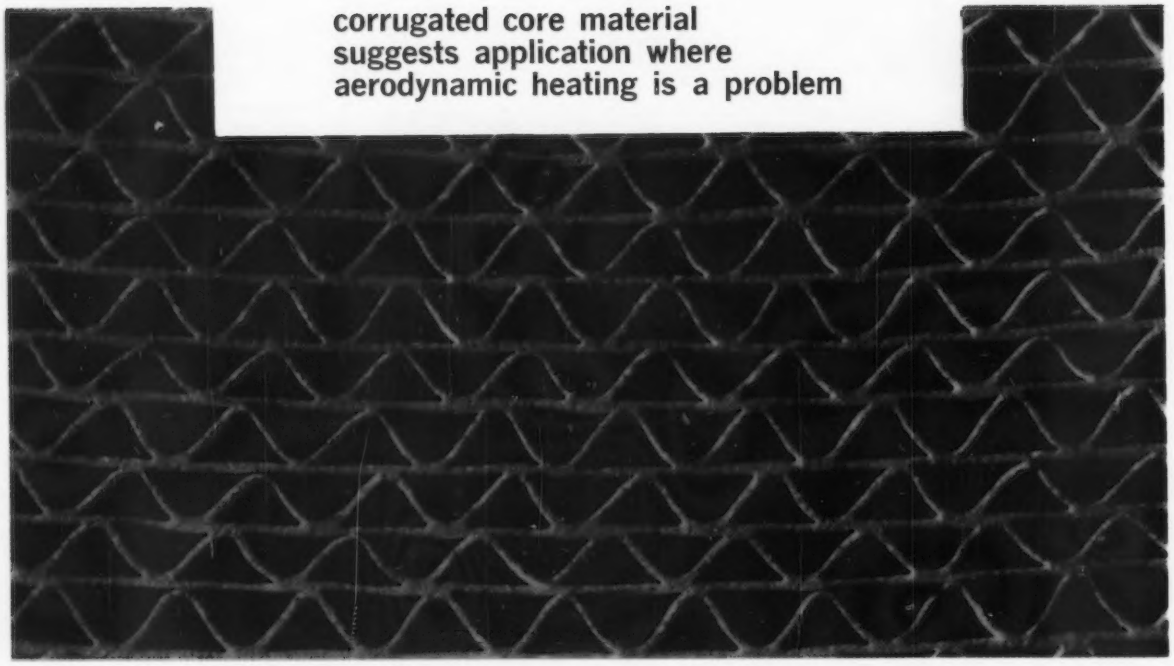
FASTENERS FOR AIRBORNE WEAPONS SYSTEMS

SAVERS

ceramic honeycomb

corrugated core material suggests application where aerodynamic heating is a problem



Microphotograph of typical section of Cercor material shows close control of wall thickness. Structure is magnified 100 times. More precise "peak-to-rally" alignment is expected as process is refined.

Add ceramic honeycomb to the list of new materials swelling the arsenal of aircraft and missile designers. The latest addition is a development of the glass industry (Corning Glass Works) and is characterized by:

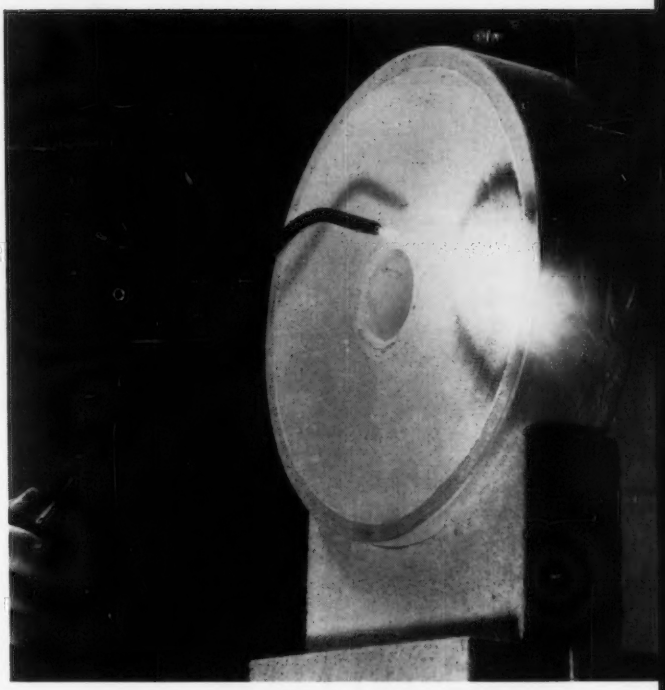
- good resistance to thermal shock
- extremely low coefficient of thermal expansion
- bulk specific gravity of 0.5

The ceramic honeycomb has been fabricated from a number of base materials, including Pyroceram, a glass-ceramic receiving attention for missile nose cones. All materials evaluated to date have exhibited the ability to operate at 1290°F continuously with low thermal expansion. Peak operating temperature is about 1800°F.

The trade name, Cercor, has been given to the materials and the process by which they are made. Cercor structures are multiple layers of thin ceramic sheets, each separated by a similiarly thin ceramic corrugation. In cross section, the material resembles several layers of corrugated paper-box containers, or a metallic sandwich material called "truss-core."

Though not mentioned by the manufacturer, the bonding mechanism which holds the thin (0.005 in.) sheets and corrugations together is a fusion of the base materials, no adhesive is used. Protective inner and outer layers are formed over the Cercor by a tough coating of

Present production equipment is geared to making disk material. Largest shape fabricated is a 20 in. diam shape. Blow torch applied to core has no effect.



CERCOR DATA

(Pyroceram Code 9608 Base)

Bulk specific gravity	0.5
Specific gravity of material	2.6
Melting temperature	1250-1350° C
Specific heat (25° C)	0.20 cal/gm
Mean specific heat (25-400° C)	0.24 cal/gm
Linear coeff thermal expansion (25-300° C)	1 x 10-7/° C
Long time no lead max. operating temp.	700° C
Compressive strength:	
Parallel to cell	2000 psi
Normal to cell, parallel to flat	400 psi
Hole size average	0.095 in. long 0.045 in. high
Corrugations/in.	20
Open frontal area	75-80%
Surface area	1500 ft 2/ft3
Wall structure	Porous, permeable
Web thickness	0.005 in.
Max diam presently available	20 in.
Max cell depth presently available	3½ in.

special ceramic material with matching coefficient of thermal expansion. Metal such as Kovar might also be used as a sandwich skin but expansion would not match as closely.

Applications

Extremely low expansion up to 570°F, coupled with high surface area, suggests Cercor's suitability as a structural material where aerodynamic heating is a problem. Cellular passages could be used to circulate liquid or gaseous cooling media. This approach has been considered for cooling missiles and space craft during reentry.

It is expected the new material will find application in gaseous heat-exchangers, air preheaters and after coolers, and in structural insulations in non-airborne usage.

Present equipment is set up for fabrication of disks and columnar sections but other shapes are possible, as illustrated.

Available Cercor materials have a compressive strength parallel to the corrugations, of 2000 psi. Surface area of 20 hole/in structure is 1500 sq ft/cu ft of material. Of the total face area 75 to 80 percent is open space. Density is 30 lb/cu ft.

✦

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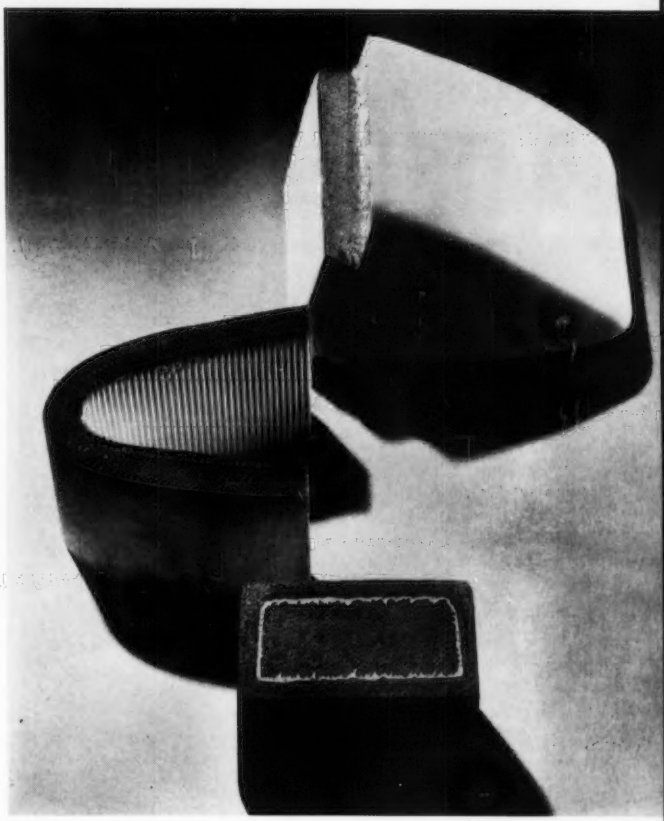
The Editor
AIRCRAFT and MISSILES MANUFACTURING
Chestnut & 56th Sts., Philadelphia 39, Pa.

Cercor material thin-walled ceramics formed into lightweight honeycomb structures. Shown are various shapes possible with this new material. Top: wedge-shaped piece, cut open to show cellular construction and ceramic rim; middle: U-shaped corrugated cellular structure; bottom: simple Cercor shape, with heavy ceramic protective rim. ▼



Striped areas indicate use of magnesium sheet in the fuselage. Titanium skin aft of cockpit is to protect structure against the blast of hot air ejected from air conditioning system. Mach 2 interceptor and Sparrow II ordnance are threatened by economic axe.

Lightening the Arrow

magnesium-titanium teamwork contributes to swiftness of mach 2+ interceptor

About 500 lb of magnesium and 600 lb of titanium lighten the airframe of Canada's CF-105 Arrow interceptor-fighter. In overall size, the CF-105 nears that of Convair's supersonic bomber, the B-58 Hustler.

The current version of the Arrow Mk 1 is powered by two Pratt & Whitney J75 turbines. The Mk 2 series, to be completed during the forthcoming months, will be equipped with the lighter and more powerful Orenda Iroquois turbines. Use of magnesium and titanium structure has also contributed to the superior thrust-to-weight ratio of 5:1 of the Iroquois. Magnesium castings in this engine range from less than a pound to 100 lb.

The extent of magnesium and titanium sheet skin used on the Arrow is illustrated in the striped profile picture. Most of the magnesium skin panels required moderate two or four-directional forming. Avro accomplished this by novel vacuum-forming technique related to the metal-to-metal autoclave bonding which is also widely used in the Arrow.

In vacuum forming, a magnesium blank is taped to a pre-formed heavy aluminum master skin. The assembly is padded in felt and enclosed in a polyvinyl alcohol bag. The bag is then evacuated, causing the magnesium blank to hug the master skin form. Curing the bagged unit in an autoclave at 350°F completes the forming. This technique is also used for severe one-directional forming.

Although the autoclave forming is primarily considered suitable for short-run production, Avro believes the vacuum technique could also be adapted to conventional heated forming dies.

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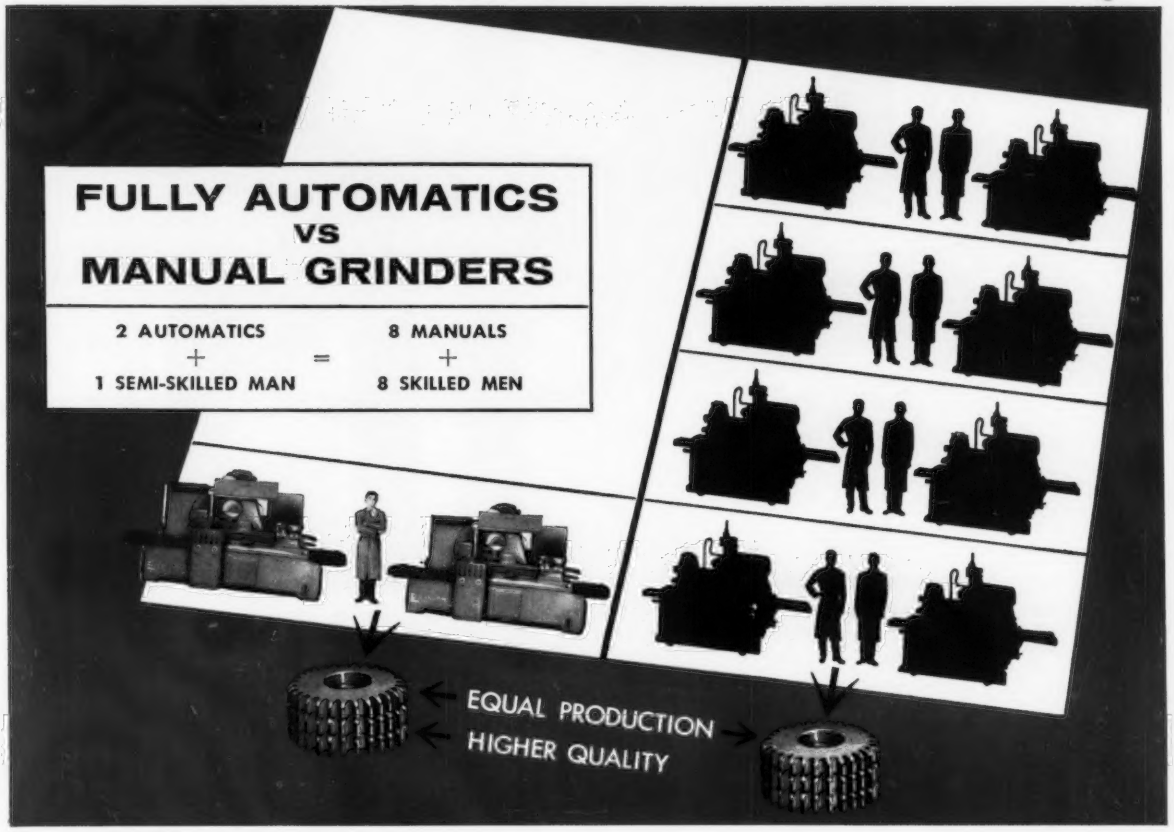
Magnesium sheet in evacuated plastic bag is shown being moved into autoclave for curing cycle.

Precision gear grinding economy



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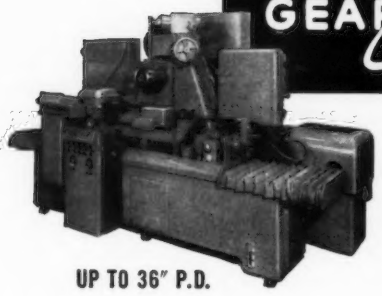

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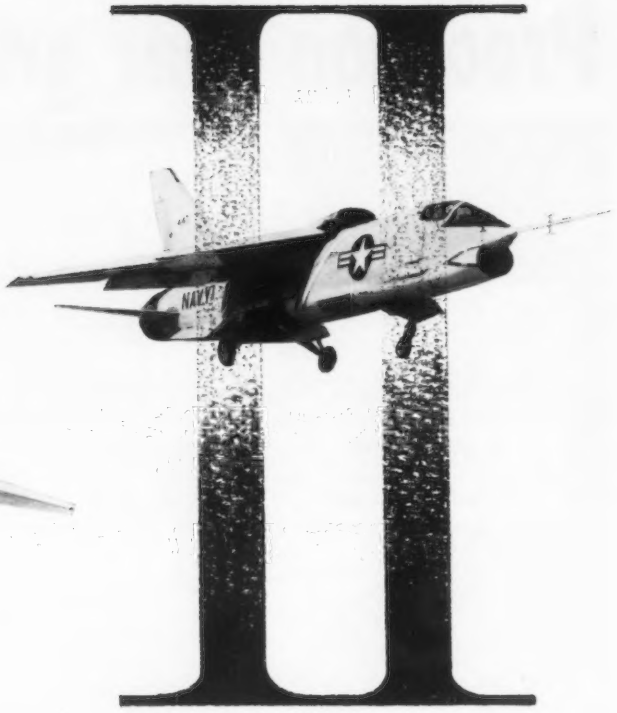
Titanium spot-welded panels in Crusader I total 650 lb. Major application was around exhaust area.



Crusader II uses titanium in same general areas as Crusader I.

titanium

Production application of titanium to the F8U-1 Crusader represented a major advance for titanium airframe design and fabrication at Chance Vought. This advance was made possible through the efforts of engineers and production personnel who worked as a team to pioneer the development of spotwelding techniques for joining titanium skins, frames, and bulkheads.

At the time when spotwelding of titanium aircraft parts was first specified in the F8U-1 fuselage aft-section, many users of titanium considered spotwelding of the alloyed metal impossible. However, the development of acceptable techniques provided a minimum-weight aft section structure in the F8U-1, and later F8U-2, which satisfied design requirements in the temperature range experienced.

From this background of titanium fabrication and design experience, Crusader III F8U-3 aft section structure was developed. Though the new aft section was larger, it was possible to design a structure for the III with less weight per sq ft than was achieved for the I and II. For example, a similar access panel weighs 2.3 lb/sq ft when built of conventional, original structure, as compared to the lower weight of 1.6 lb/sq ft when employing methods devised for the F8U-3. In addition, to the weight savings, substantial manufacturing cost savings were realized.

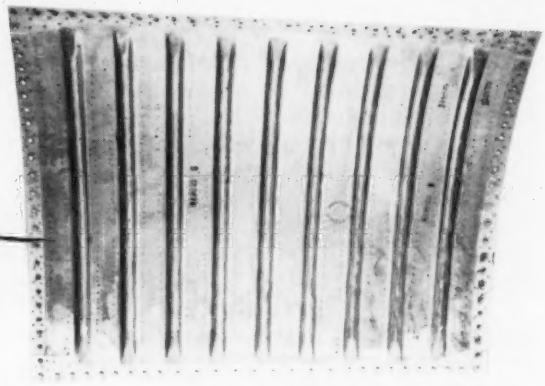
Design Problem

The design problem was to decrease the number of frames, stiffeners, and angles, and still make a stronger unit. This was accomplished by using a composite construction: commercially pure titanium beaded inner-skins, spotwelded to 8 Mn alloy outer skins.

Development of the composite panel concept in titanium required close cooperation of designers, structures engineers, manufacturing research engineers, and production design engineers.

The Crusader III F8U-3 aft section structure requires five bulkheads to provide attachment point for the tail surfaces, and for joining the aft section to the fuselage mid-section. The basic structure is completed with five longerons

Overhead view of Crusader III clearly shows titanium after-fuselage.



Typical titanium panel used in F8U-3 is a composite beaded structure. Inner beaded skin is commercially pure titanium and is spotwelded to 8 Mn alloy outer skin.

Crusader series sees increased and refined applications of spot-welded titanium panels; design-production coordination important to achieving producibility

by **C. P. Smith,** production design supervisor, Chance-Vought Aircraft Corp.

plus two keels in the arresting hook area. To this skeleton structure the fixed and removable composite panels are attached to complete the aft section structural assembly. In addition to the design and manufacturing advantages, this type construction provides a clean assembly for servicing because many separate pieces and raw edges of sheet metal details are eliminated.

New Forming Technique

Previous forming techniques used in fabricating titanium parts required separate stress-relieving operations and fixtures. Chance Vought manufacturing research engineers developed a technique that eliminates the separate stress relieving operation. Final forming and stress relieving are accomplished in one operation through the application of heat and pressure during the press forming operation of the beaded skins. Using this technique, curved panels as large as 32 x 40 x 6 in. have been formed successfully. With this design concept, only 9 fixed composite panels and 4 removable composite panels are required to completely "skin" the aft section.

This design approach represents a major producibility improvement in titanium structure because of the substantial reduction in number of detail parts as compared with "conventional" titanium construction. In addition to the major advantage of reducing the number of large sheet parts, additional advantages have been realized: reduced number of fasteners; reduced usage of titanium material per equivalent part, reduced detail fabrication and assembly time; reduced weight; and reduced maintenance time.

Spot Welding Techniques—General

Design allowable for spot welding titanium assemblies are based on extensive fatigue testing and conventional lap-shear and tension testing. Care is exercised to avoid extremes in application of thickness combinations; preference is for multiple build up of light gages.

All titanium material is purchased in accordance with Chance Vought's own chemical composition specifications. Parameters are more stringent than those of the industry as a whole.

continued on next page

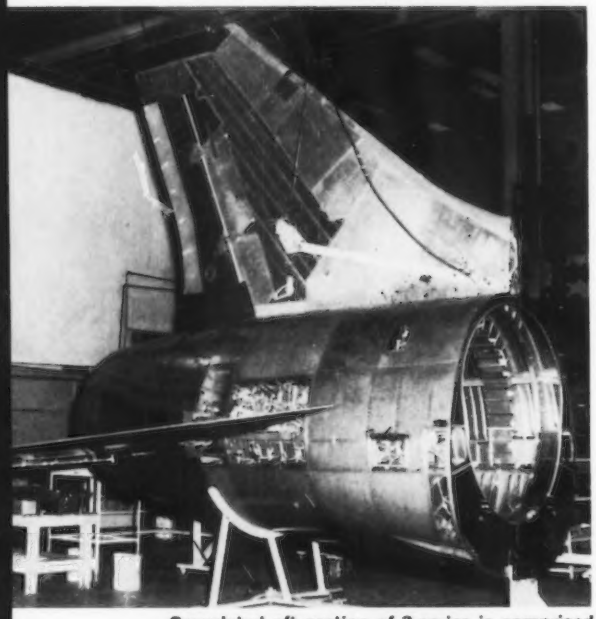
I II III titanium... continued

Fusion welding of titanium demands complete inert-gas protection of the hot weld zone to minimize contamination. In spot welding, however, the close proximity of adjacent surfaces at the weld zone, in combination with the very short duration of the weld cycle, makes involved special shielding unnecessary. The low electrical and thermal conductivity of titanium are definite advantages in spot welding.

Surface preparation is important, as it is with other metals. Very close quality control is maintained beginning with the cleaning cycle and continuing through the spot weld process. A conventional nitric-hydrofluoric acid pickle is used on all details to remove residual mill contamination and/or scale introduced by hot forming operations. Oxide film on surfaces being joined could be fused into the weld nugget and lead to drastic reduction in the ductility of the weld.

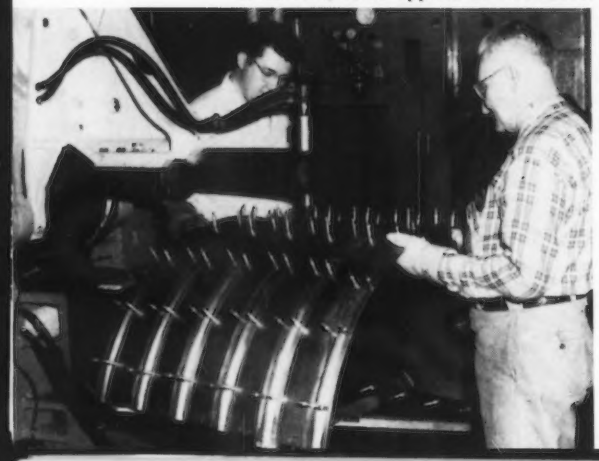
Spot Welding Equipment

Good spot welds can be obtained on most machines which enable accurate control over the four basic spot welding parameters: welding current (amperes), duration of welding current (cycles at 60 cycles sec), force applied to the welding electrodes (lb), and electrode geometry. Various data indicate that each of these parameters may vary to a certain degree without appreciably reducing weld quality. But once the optimum settings are obtained for a given applica-



Completed aft section of 3-series is comprised of 9 fixed composite panels and 4 removable panels. Typical beaded panels are visible just inside forward bulkhead.

Spotwelding is effected on machines which enable accurate control of four basic parameters; amount of current, duration of current, force applied at electrodes.



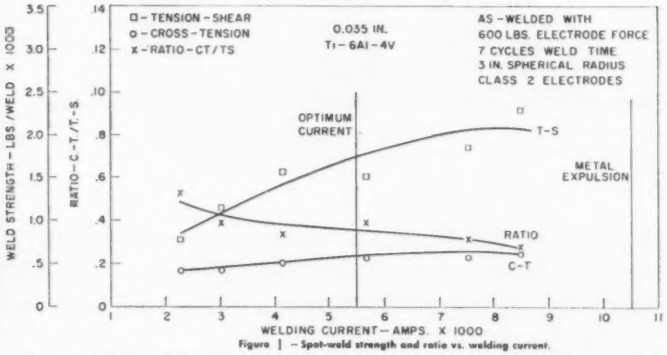


Figure 1 – Spot-weld strength and ratio vs. welding current.

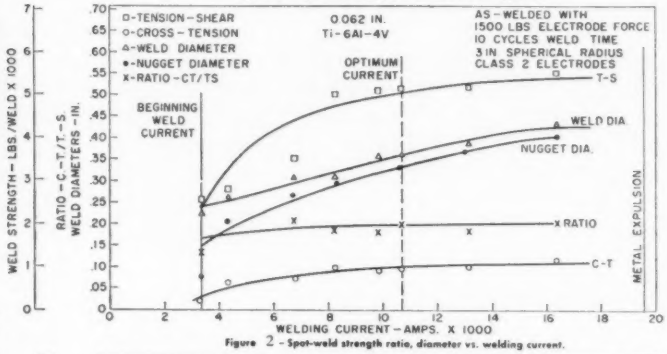


Figure 2 – Spot-weld strength ratio, diameter vs. welding current.

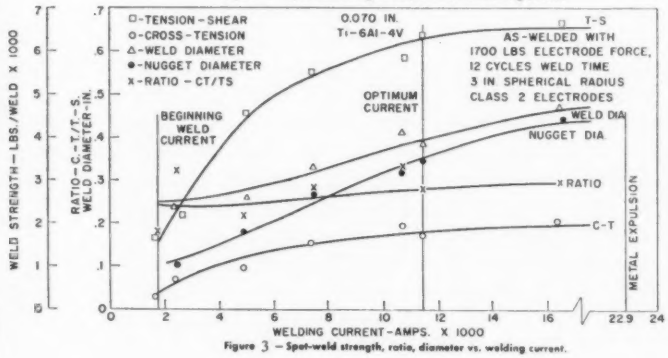


Figure 3 – Spot-weld strength, ratio, diameter vs. welding current.

tion, it is desirable to have enough control over the parameters to obtain reproducible results. Light gauge sheet (less than 0.040 in) can be welded with most of the 30 KVA, 60 cycle, single phase, rocker arm type machines. Because of the higher currents and electrode forces required for heavier gauge sheet, the larger press-type machines are more suitable.

Electrode Type

The most satisfactory electrodes are the spherical faced, copper alloy types. They allow a wide range of current settings from the point of no-weld up to the point of metal expulsion. Also, higher weld strengths can be obtained with larger weld nuggets, better control of penetration, less elcctrode indentation, and less sheet separation for given set of welding conditions in comparison

Panel of earlier design for use in F8U-1 used more stengthening angles and stringers. Panel redesign reduced cost, weight, and fabrication time.

Final forming and stress-relieving of newly designed panels is done in one press operation. Panels as large as 32x40 in., with a curvature depth of 6 in. have been formed by this process.

to other types of electrodes. The truncated cone electrodes have been satisfactory for some cases but often produce non-uniform sheet separation and excessive electrode indentation.

Joint Lap-Spot Spacing

When spot welding overlapped sheet joints, it is important to maintain a minimum joint overlap great enough to avoid end-tearing of the sheet in tension-shear loading. Insufficient overlap will result in metal expulsion and a very weak spot at the weld settings which would ordinarily be the optimum settings with proper joint overlap.

In most materials, when spot welds are placed too close together, a portion of the current required for the second weld is shunted through the preceding weld. This, of course, means that the actual weld current is somewhat below the optimum and the resultant weld may be weak because of low heat, even though the machine is set at the optimum weld current.

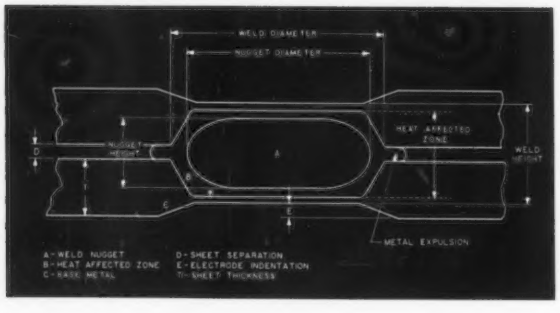
With titanium's high electrical resistance, current shunting is not as critical a factor as with most other materials and weld strengths are not appreciably reduced until spacings are small enough to produce spot overlap.

TABLE I

Settings Used For Spot Welding Ti-6Al-4V

Sheet Thickness (Inches)	0.035	0.062	0.070	0.093
Joint Overlap (Inches)	1/2	5/8	5/8	3/4
Squeeze Time	60	60	60	60
Weld Time, Cycles	7	10	12	16
Hold Time	60	60	60	60
Electrode Type	(3" spherical radius, 5/8" diam, Class 2 Copper)			
Electrode Force (Pounds)	600	1500	1700	2400
Weld Current (Amps)	5500	10600	11500	12500
Cross-Tension Strength (Lbs)	600	1000	1850	2100
Tension-Shear Strength (Lbs)	1720	5000	6350	8400
Ratio C-T/T-S	0.35	0.20	0.29	0.25
Weld Diameter (Inches)	0.255	0.359	0.391	0.431
Nugget Diameter (Inches)	—	0.331	—	—
Weld Penetration (%)	—	87.3	—	—
Electrode Indentation (%)	—	3.1	—	—
Sheet Separation (Inches)	0.0047	0.0087	0.0079	0.0091

Fig. 4. Schematic diagram of a spot weld, indicating weld geometry terminology employed in describing spot welds and their quality.



Welding Current

After selecting the recommended electrode force and welding time for a given sheet thickness, the optimum weld current must be established. This is the most important spot welding variable and determination of the optimum current setting is best accomplished by welding some test specimens and choosing the weld current on the basis of weld strength, sheet separation, electrode indentation, weld diameter, and percent penetration. Fig. 1, 2, and 3 illustrate the variation in some of the welding current below and above those selected as optimum for the various gauges.

It can be seen that if one is not concerned with some of the parameters such as sheet separation, etc., higher weld currents (up to the point of metal expulsion) may be used to obtain stronger welds. There is a definite decrease in weld strength and sheet separation at the point of metal expulsion.

Additional Machine Settings

The electrode forces are applied to the sheets being welded for a period longer than actually required for the welding current to flow through the spot. The total period of time consists of squeeze time, weld time, and hold time. The squeeze time is the time that the electrodes hold the material together at the required force before the weld current is actuated. The weld time is the time of actual current flow, and the hold time is the interval during which the electrodes are in contact with the material after the current flow has stopped. Solidification of the weld nugget takes place during the hold time. Both the squeeze and hold times are generally set at about 20 cycles duration, but can be varied according to the sheet gauge. In light gauge sheet, the weld nugget is solidified in less than 20 cycles hold time and adjustments in these machine settings can be made in accordance with production requirements.

An example of the data obtained during the course of establishing optimum weld currents for various gauges of Ti-6A1-4V is presented in Table I. Data were compiled by Titanium Metals Corp. of America (TMCA).

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lunar-probe propulsion

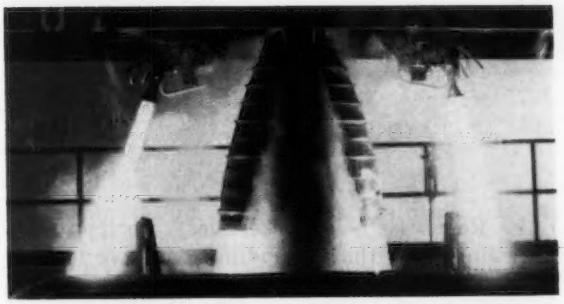
conglomerate of rocket types used in three-stage vehicle; first stage engine of tubular construction

One hundred fifty thousand pounds of thrust roaring from the Thor Able first-stage rocket, in less than 2½ min provided almost ¾ of the total thrust that sent Pioneer I 79,000 mi into space.

Thrust chamber of the rocket is fabricated from nearly 300 high-nickel alloy tubes, which during manufacture are aligned longitudinally on a welding mandrel that conforms to the inside dimensions of the rocket. Steel straps snug the tubes to the mandrel so that not more than 0.003 in. gap exists. Straps are welded in place and gaps between the tubes are closed by brazing. A heavy steel band welded to the throat of the chamber provides an attachment for the actuating rod which moves the rocket on its gimbal mount. After the chamber is removed from the welding mandrel, the injector plate and other accessories which are related to providing regenerative cooling are added. In operation, RP-1 fuel flows through the tubes before it is mixed with lox at the business end of the injector plate.

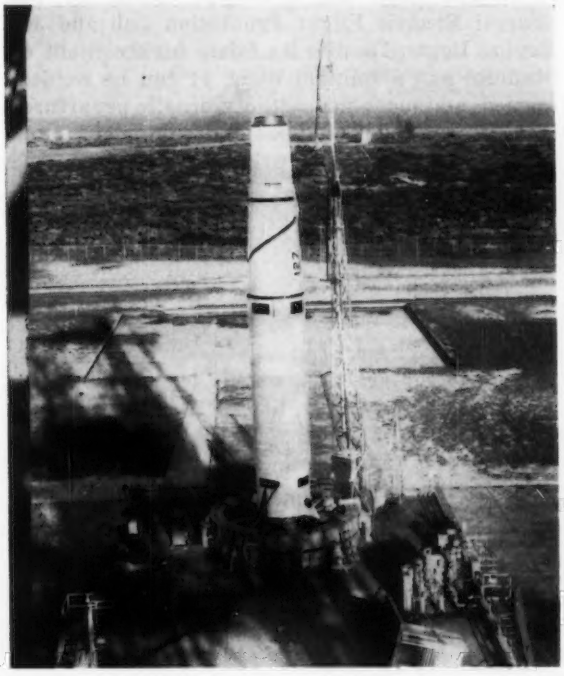
First stage propulsion and vernier engines (AMM, October 58) for the Air Force lunar-research vehicle are produced by Rocketdyne. Second stage propulsion, essentially a refined Vanguard, is supplied by Aerojet-General. It is liquid fueled, provides about 7500 lb thrust, and is rotated after separation of the first stage by eight spin rockets. Third stage uses a solid propellant rocket engine of 2500 lb thrust. Alleghany Ballistics Laboratory is the supplier. Terminal vehicle includes a retro-rocket supplied by Thiokol.

During the lunar shot of October 11, all propulsion units operated as expected except the terminal rocket. When it became apparent that a lunar orbit was not possible, IGY personnel attempted an Earth orbit of Pioneer by using the terminal rocket. It did not respond, purportedly because of unexpected temperature conditions.



First stage rocket of Thor and vernier engines are tested prior to installation in lunar vehicle. Vernier engines provide minute directional control on Thor.

Thor vehicle of type used in the lunar probe, sits partially assembled on launch pad at Cape Canaveral.



flash-welding René 41

nickel-base alloy used in J-79 series, hot-strength, weldability, machinability vital to manufacture of afterburner rings

by John P. Kushnerick

Rene' 41 is a nickel-base, precipitation-hardening alloy that is finding extensive use in the J-79-9 turbojet engine. Possessing high strength in the 1600 to 1800°F temperature range, the alloy is used in the compressor rear frame and in afterburner rings of this engine. The J-79 powers the Convair B-58, Lockheed F-104, North American A3J, McDonnell F4H, and other high-performance aircraft.

The alloy was developed jointly by the General Electric Flight Propulsion Lab and Jet Engine Depts. Despite its fairly high content of titanium and aluminum Rene' 41 can be welded, formed, and machined without drastic departures from conventional methods and equipment.

Weldability is of prime importance in the fabrication of the rear frame support-rings. These components are formed from Rene' 41 bar stock by bending to ring shape and flash-welding at King Fifth Wheel Co., Mountain Top, Pa. The following steps are essential in fabricating the rings:

- Precision sizing bar-stock length.
- Bending bar stock to desired ring-size.
- Flash-welding, to close ring.
- Grinding flash-welded area.
- Heat treating.
- Precision sizing by expanding or shrinking.

Sizing and Bending

Bar stock is received in the annealed condition (B50T44A-S5) and is immediately suitable for abrasive-wheel cutting. The stock is sized, taking into account bending and flash-welding allowances. During the bending operation, shrinkage occurs equal roughly to three times the bar thickness, i.e., 1 in. bar stock with a 20-in. length will produce a ring of only 17-in. circumference. During the flash-welding operation size is further reduced about two in.

Rene' 41 is cut to size with a conventional 16x⅛-in. dry wheel, turning at 3500 rpm.

Although René 41, has more "springback" than conventional aircraft steels, standard Lake Erie forming presses with 100 and 200-ton capacities are used to bend the bar stock to circular shape. The stock is pressed between I.D. and O.D. dies which conform to about ¼ the circumferential arc of the final ring. Multiple passes are hence required. In the case of Rene' 41, about 10 passes are used to form a 20-in. ring.

Flash Welding

Closing of the ring is accomplished on one of two flash welding machines (Federal Welding, Warren, Ohio). There are three steps in the welding sequence: preheat, flash, and upset. The ring is clamped firmly in the welder, with the ends under compression during the entire cycle.

During the preheat cycle high-amp low-volt electrical impulse is used to burn off about 1/16 in. of each face. This prepares the surface by eliminating grease and other contaminants which may have been introduced in sizing and bending. On the 750-kva machine, a typical René 41 ring with a 3.9-sq in. cross section the settings are 6.2 v at 48,000 amp. Compressive force is

Flash-welding is performed on a 400 kva or 750 kva machine. Three steps in flash-welding are: preheat, flash and upset.

153,000 lb (or about 39,200 psi). This operation is done manually, i.e., the operator controls the time cycle (about 1 min).

Flash and upset cycles are controlled automatically. During the 15-sec flashing cycle, current is reduced to 90 per cent of preheat, and pressure is reduced to 134,000 lb. About 13/16 in. is burned from each face in flashing.

The upset cycle follows immediately and automatically. During the 1/6 sec (10 cycles) that upsetting requires, current is reduced to 35 per cent of preheat, pressure is increased to 153,000 lb and hot metal is expulsed in the area of the weld, further reducing ring circumference. It is during upsetting that the final ring-closure is actually effected. With over 15 months' experience in welding Rene' 41, King has found that these techniques produce welds with at least 90 per cent the strength of the parent material.

Heat Treat and Final Sizing

After grinding away the flash (excess metal which is expulsed and solidifies in the area of the weld), the rings are heat treated in an electric furnace. Cycle is:

- Preheat, 1000°F for 60 min.
- Final heat, 1950°F for 120 min.
- Quench in water.

This cycle produces a surface with about 300 Brinell hardness and tensile strength of about 190,000 to 200,000 psi at room temperature, in the parent material. Weld has about 90 per cent this strength. At elevated temperature (1400°F), minimum acceptable tensile strength after aging is 115,000 psi, and three per cent elongation. Weld areas must have at least 50 per cent of these values at 1400°.

Final sizing is done on a 500-ton expandable-mandrel machine. Rings are about one per cent (circumferentially) and must be stretched to size. Stretching imparts desirable physicals to the material.

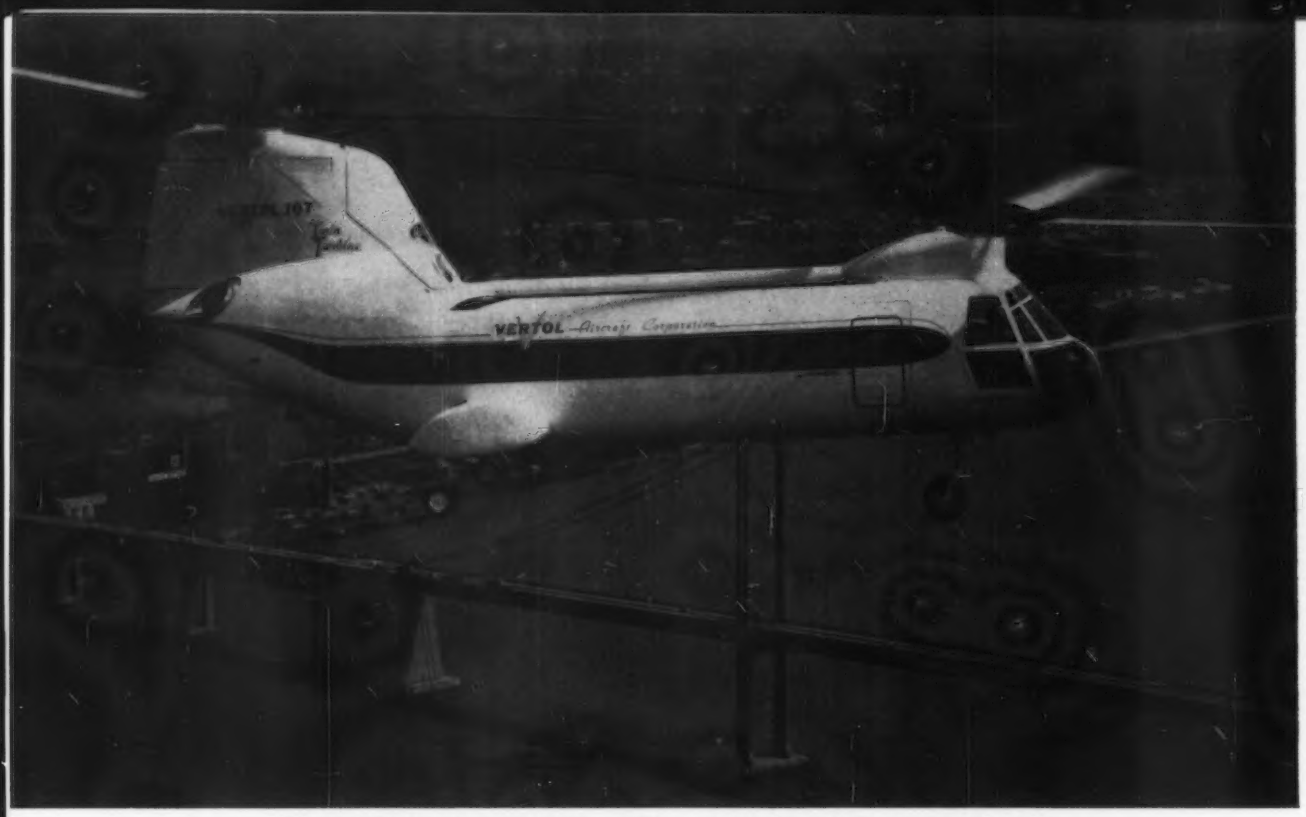
Finally, a heat-treat cycle identical to the post-welding heat-treat is given prior to shipping the rings.

Rings are machined to final shape at General Electric, Evandale. Carboloy Grade 883 carbide cutting-tools are used.

✦

After grinding away flash (metal expulsed in area of weld), rings are brought to exact size by expanding. Minimum of 1 percent circumference expansion is required.

Compressor rear frame on J79-9 is Rene 41. Flash welded rings are used with this part on: inner and outer combustion casing (on side shown), and outer combustion casing (side not shown).



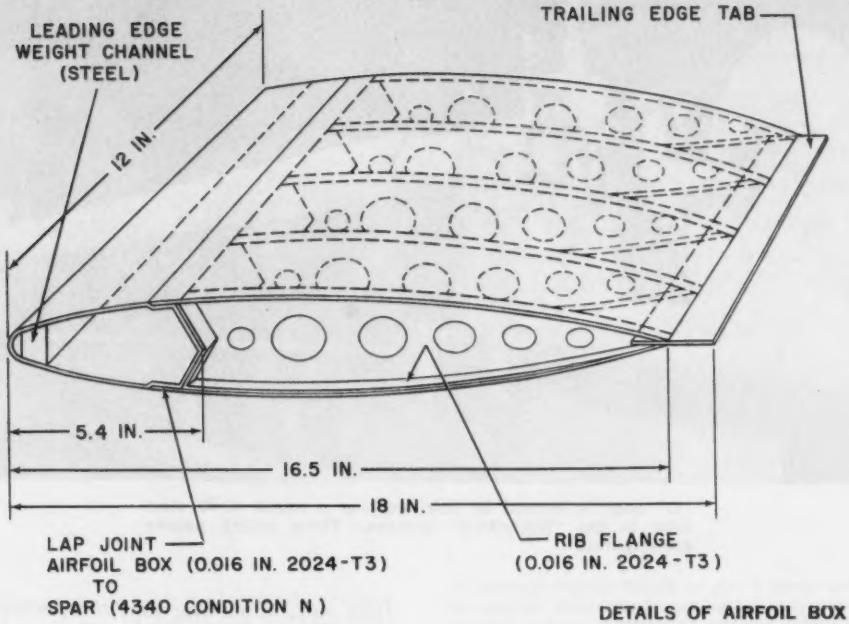
Model 107, Vertol's twin-turbine prototype of the Army YHC-1 is equipped with interchangeable metal rotor blades. Commercial Model 44 is similarly equipped; some H-21's now in service with wooden blades will be converted.

interchangeable rotor-blades

aluminum airfoil-boxes are adhesively bonded to steel spar at Vertol; each blade component weighed before assembly to match master-blade weight

by John P. Kushnerick

AIRFOIL BOX DETAIL
JOINED WITH NARMCO 4021 ADHESIVE SYSTEM



DETAILS OF AIRFOIL BOX

Helicopter rotorblade design and manufacture have undergone a slow and painful transition from wooden blades, changeable only in complete sets, to metal blades, individually interchangeable.

The advantages of a metal rotor blade, aside from the economics of interchangeability are:

- Greater inherent strength.
- Greater resistance to handling damage.
- Greater resistance to erosion damage.
- Greater fatigue life.

It is readily apparent that an individually interchangeable all-metal rotor blade should be a major objective of every helicopter manufacturer. It has not been achieved by all to date.

Only in recent months has Vertol Aircraft Corp., second only to Sikorsky in this country, achieved the goal. The Vertol blade, essentially a series of aluminum "boxes" adhesively bonded to a steel "D" shaped spar, has been approved by CAA for a 6000 hr service life. It will be used on future H-21, 107 and 44 models.

Blade Description

The Vertol metal blade is about 22 ft in length. It has a chord of 18 in., which consists of an NACA 0012 airfoil on a 16.5 in. chord, with a 1.5 in. trailing edge extension in the form of a continuous tab.

A zinc plated 4340 steel "D" spar is the main structural member. This spar comprises about 33 per cent of the chord. The after section of the chord is formed by 2024-T3 aluminum airfoil - boxes, bonded to the steel spar with Narmco's Met bond 4021 adhesive system. Each box is 12 in. in length and consists of a top and bottom skin and 5 forming ribs, all preassembled with the 4021 adhesive system. A total of 17 boxes are used along the length of the "D" spar and are joined at the trailing edge by the continuous 2024-T6 tab which is bonded in place.

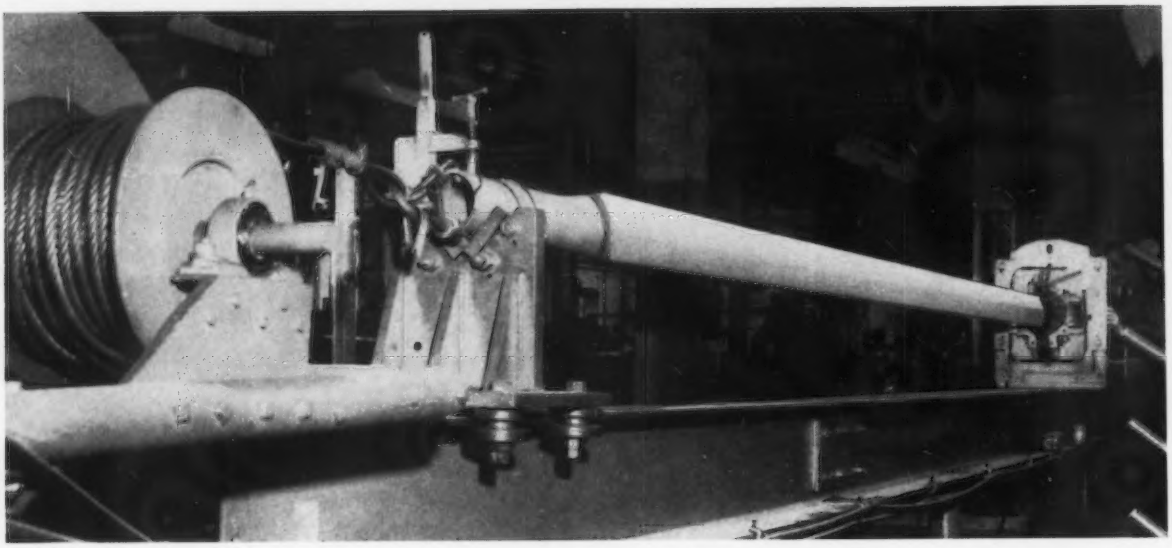
A contoured, foamed rubber spacer is used between each blade box to absorb vibration, and a Hysol filler compound is used to provide a smooth air foil at the 0.010 in. gap between boxes.

Bonded into the "D" spar is a 4130 steel leading edge balance weight which is used to lower in-service vibration levels by reducing natural frequency of the blade.

Final balancing and tracking weights are installed in the blade tip. Tip hardware is secured in place with flush head screws.

"D" Spar Fabrication

The basic spar is fabricated from a round seamless 4340 steel tube by the "Rockriting" process. The tube as obtained from Tube Reducing Corp., Wallingford, N. J., has a constant 4.300 in. O.D. with a tapering wall thickness: 0.294 in.



"D" spar is formed by cold working a round 4340 steel tube in the "Rockriting" process. Three rolling passes are required.

rotor-blades . . . continued

at the root end, to 0.050 in. at the tip end. In rockriting, the round tube is reduced to a "D" shape by cold working in a series of rollers. Three passes are used, with an annealing operation between the second and third passes.

The "D" spar is then heat treated, in a salt bath furnace and quenched in a low temperature salt. Twisting and tempering the spar are then performed simultaneously by clamping the hardened spar in a twist-fixture that gives a 7 deg wash out from root to tip. The fixture is an integral part of the tempering retort. After the spar has been clamped in the fixture, retort put in place, and atmosphere in the retort evacuated to eliminate hydrogen and oxygen, an electric furnace is used to take the spar through its heat treat cycle.

The spar with 7 deg twist is then descaled, polished with hand belt grinders, and machined at the root end. The root end is threaded so that

After shaping, twisting, heat treating, and cleaning, "D" spar is zinc plated in NaCN bath. See Table I for plating specifications.

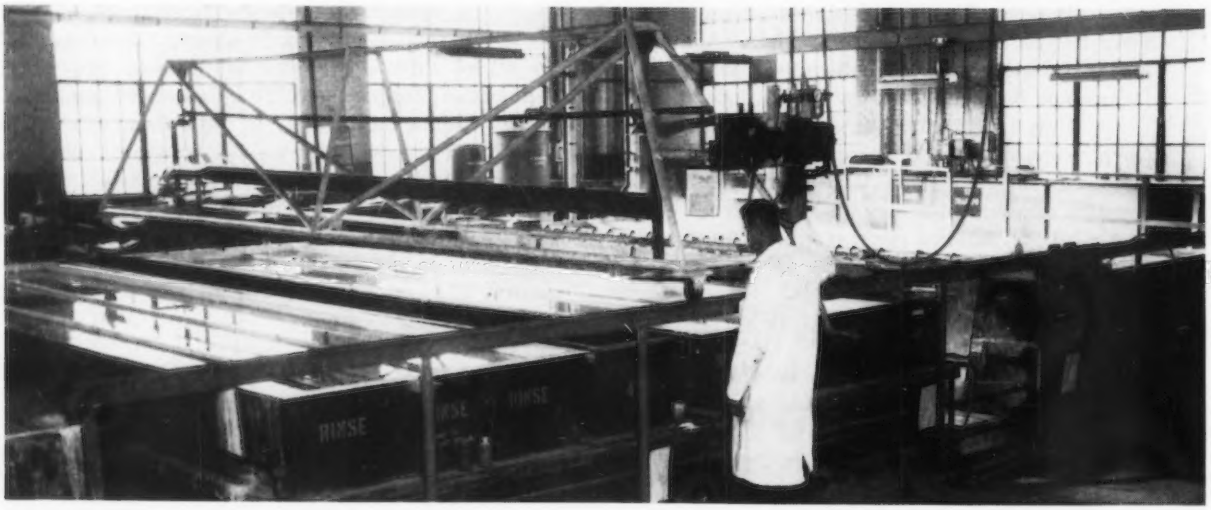


TABLE I

Zinc Plating of D-Spar

Solution	Concentration	Immersion
Alkaline Cleaner 190 to 210°F	8 to 10 oz. Wyandotte FS Cleaner per gal solution.	3 min
Rinse	Cold running H_2O.	
Acid Pickle	20 to 25 per cent by volume HCl (S.G. 1.19).	5 min
Rinse	Cold running H_2O.	
Cyanide	2 to 3 oz NaCN per gal solution.	5 min
Plating	Metallic Zn 4.5 to 6 oz. of per gal. NaOH 10 to 13 oz per gal. NaCN 12 to 18 oz per gal.	Secure spar to electrodes apply 6 short strikes at 1000 amp. Plate at 125 amp for 5 min. (Voltage 1 to 8 v, 5 to 50 amp/sft, thickness 0.0005 in.).

TABLE II

Cleaning Aluminum Details

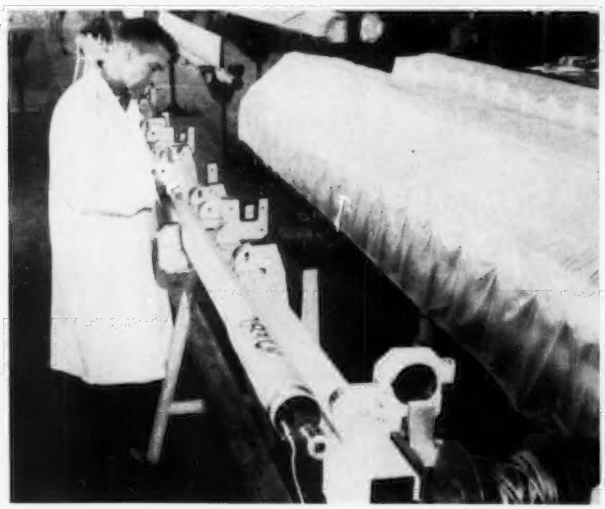
Solvent wipe	Methyl Ethyl Ketone	
Vapor Degrease	Perchloroethylene.	5 to 10 min
Alkaline Cleaner 180 to 210°F	Oakite 61, Sprex AC, Diversey 909, Clepo 86P, or Turco Aviation. 4 to 6 oz per gal H_2O.	5 to 10 min
Rinse	Cold running H_2O.	
Sulfuric Acid/ Sodium Dichromate 150 to 160°F	H_2SO_4 2.35 lb per gal sol. Na_2CrO_7 0.94 lb per gal sol.	10 min
Rinse (double)	Cold running H_2O.	
Dry	Forced hot air.	

a rotor hub attachment which mates with present taper pin lugs may facilitate direct replacement of metal blades for wooden blades now in service.

To provide corrosion and erosion protection to the steel spar it is zinc plated, except in areas to be used to effect the bonding in place of trailing edge boxes.

Spar is first sand blasted interior and exterior and thoroughly degreased in perchloroethylene. The back portion of the spar to be used in bonding is masked with multiple coats of Unichrome 323 stop-off lacquer (approx 0.006 in.). The cycle outlined in Table I is then used to effect

Flat section of spar is protected against plating by Unichrome stop-off lacquer. After zinc-plating, lacquer is removed and Metlbond 4021 adhesive applied to section of spar that will be joined to airfoil boxes. Note heating mandrel in spar.



Adhesively coated details of airfoil boxes are pre-assembled on special mounting frame before they are placed in the bonding press. Technician wearing white gloves here installs ribs on frame using Teflon sheet as parting agent.

a 0.0005 in. build-up of zinc from a cyanide bath.

After plating, "D" spar processing is complete and spar is ready to have adhesive applied to the unplated area. Stop-off lacquer is removed.

Liquid adhesive is applied to the unplated area and allowed to dry in a controlled environment (temp. 75°F, relative humidity 30 per cent) adhesive coating room. The interior of the spar is partially filled with liquid adhesive, both ends plugged, and the spar tilted several times to coat the interior of the spar with adhesive. This serves the dual purpose of providing a film for bonding the leading edge weight in place, and the secondary function of protecting the interior of the spar from corrosion.

Tape adhesive is then applied to the exterior of the spar previously liquid coated. The spar is wrapped in cellophane and stored until the time it is bonded with the air foil boxes.

Fabrication of Airfoil Boxes

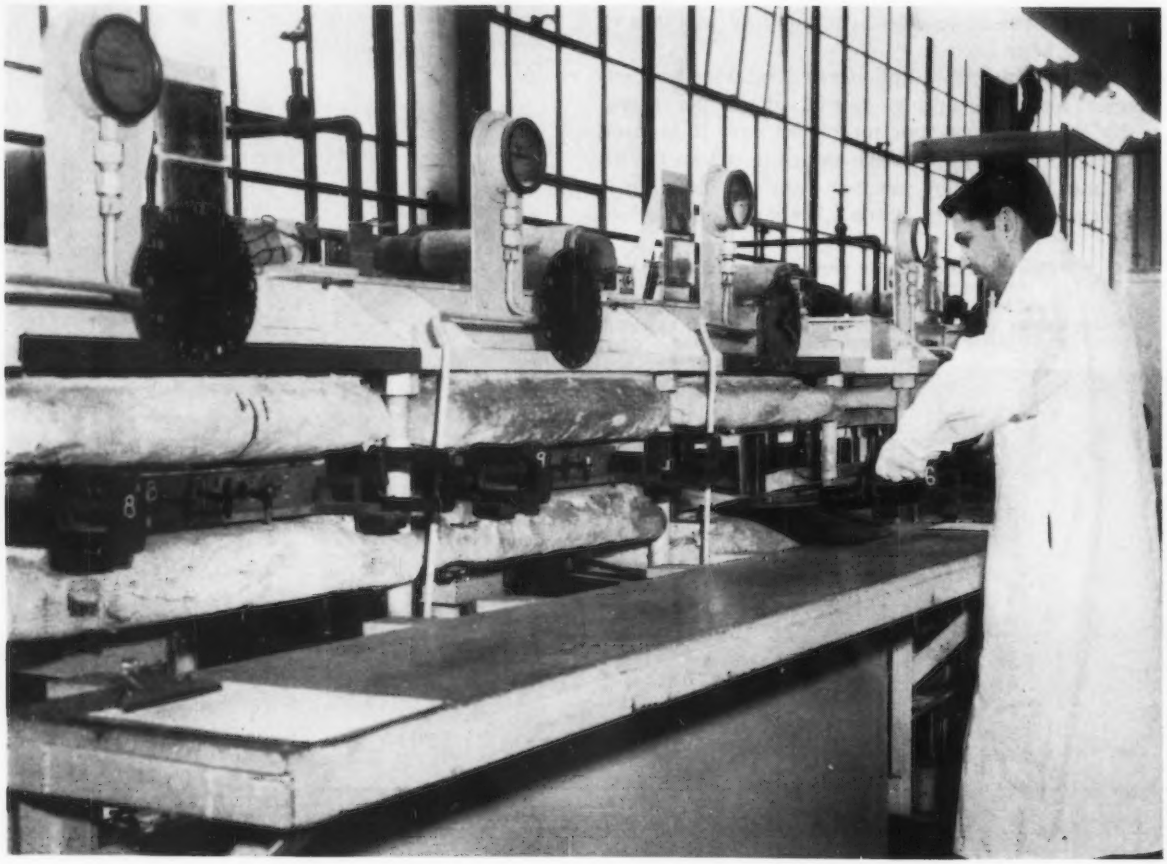
The top and bottom skins, and five ribs of each box are sized and formed from 0.016 in. 2024-T3 aluminum stock. Parts are racked and cleaned as lots by: vapor degrease, hot alkaline cleaner, rinse, sulfuric acid/sodium dichromate dip, through rinse, and hot air force dried.

The box detail parts are then removed to the controlled environment adhesive coating room. Skins are coated with Narmco liquid adhesive on one side only by brush method; ribs are coated with liquid adhesive by dip method. No part of any detail to be bonded is touched with unprotected human hands after cleaning process is begun.

Parts coated with 21 liquid adhesive are then dried at room temperature for 30 min and force dried at 250°F for 30 min to 1 hr.

Narmco Metlbond Type I tape adhesive is then applied to the faying surfaces of the box ribs. Skins and ribs are assembled in a bonding fixture and cured at 100 psi for about 4 hr within

Complete assembly, frame and box, are placed in bonding fixture. Pressure is applied to platens hydraulically, heat is applied by steam.



temperature parameters of 310 to 350°F. (See illustration for exact parameters.)

The assembled boxes are weighed serialized, and catalogued to determine which boxes may be used in combination with each other to assemble an individually interchangeable blade.

Bonding

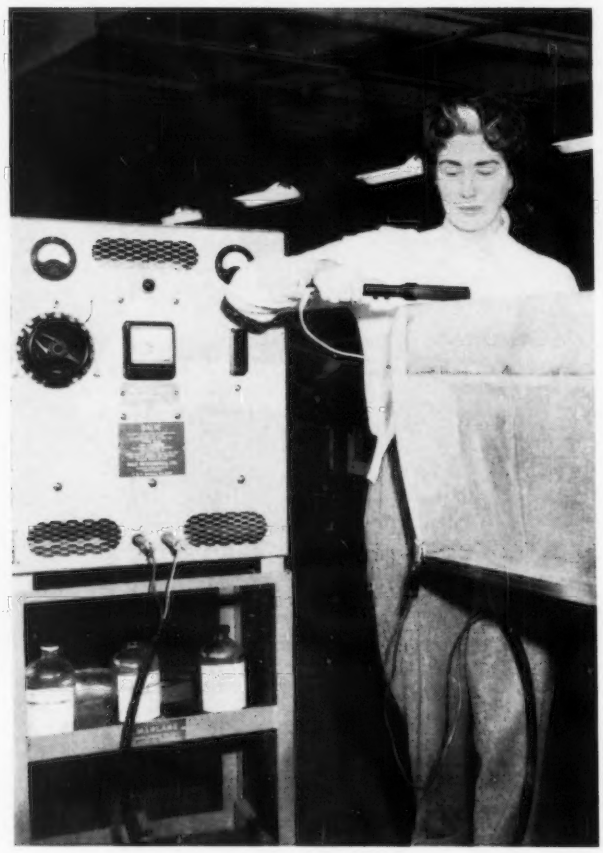
The 17 airfoil boxes and a leading edge balance weight channel are selected to fall within certain design parameters and are assembled in the main bonding fixture. All boxes and the weight are cured in one operation.

Pressure of 100 psi is applied by mechanical means, heat to 350°F is applied by electrical resistance strip. The leading edge weight channel is bonded in place at 320 to 350°F, the air foil boxes are bonded to the "D" spar at the same temperature with slightly varying time cycles.

The continuous trailing edge strip is bonded in place in a separate fixture subsequent to the main bonding operation.

Tip hardware fittings, tip cover, and root end socket are added to complete the rotor blade.

Installation of tip hardware to complete blade requires drilling and grinding for flush-head rivets, original zinc plating is disturbed in small areas. Touch-up plating is done with Dalic Type 1068 apparatus.



During this operation clean up of glue squeeze-out is effected by hand. Gaps between boxes are filled to effect a smooth air foil and trailing edge is straightened.

Blades are then painted, and balanced by teetering against a master blade. The check against the master insures individual interchange ability.

Adhesives—Bond Strength

Narmco Metlbond 4021 is a two-part adhesive system consisting of a liquid and an unsupported film. The liquid, known as Metlbond 4021 Type II, is 10 per cent solution of phenolic resin in a 91 per cent methyl ethyl ketone and 9 percent toluene solvent mixture. The film is a modified phenolic thermosetting resin. The adhesive system is classified by MIL-A-5090B as two part Class E adhesive.

Adhesive is tested upon receipt from Narmco for lap shear and peel strength valves, and is subsequently tested every 96 hr after it is placed in use.

During blade fabrication the first airfoil box and at least one box assembly in every subsequent 50 boxes produced in each bonding press are tested to destruction.

In this test the boxes are cut apart on a bandsaw, and the rib-to-skin bond subjected to a peel test on a Scott Peel Machine. Each skin to rib bond should provide at least a 14 lb continuous pull on the peel tester.

Tested in combination the following values show acceptable limits. All failures within 80 per cent of the 14 lb/strip valve are accepted with special note, lower valves are cause for reject.

No. Strips	*Report*	*Reject*	*Area of Bond*
4	44	40	Root box
5	55	50	Standard box
6	66	60	Continuous tab

Peel test, though not yet accepted by military, is an effective way of testing bonded joints for continuing failure. That is, valves do not necessarily reflect the stresses which will initiate failure in a bonded joint, but give a measure of the stresses needed to continue failure once it is started.

The entire bonding cycle was qualified to CAA and WADC specifications about one year ago. Tests were conducted at room temperature, 180°F, —65°F, and after 30-day salt spray exposure within the temperature parameters called out in Vertol bonding specifications. In every case the lap shear valves equalled or exceeded CAA and WADC strength specifications.

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hotter aluminum

lithium in X-2020 alloy raises operating temperatures 100°F

In an attempt to have aluminum maintain its long standing reputation as the primary aircraft structural material, Aluminum Co. of America (Alcoa) has pushed ahead more than 100°F temperatures at which aluminum may be used with its X2020 alloy.

Conventional aluminum alloys begin to lose physical properties in the 250 to 350°F range, this has placed some limitations on their use in jet aircraft and missiles which generate skin temperatures in that order near 1200 mph.

The addition of a little over 1 percent lithium, lightest of all metals, has extended the useful range of X2020 alloy to 400°F. Modulus of elasticity has been improved some 8 percent over that of the conventional alloys. The addition of lithium has also rendered a material nearly 3 percent lighter.

The alloy, available for some months, lends itself to standard mill and aircraft production practices.

Thermal Practices

Recommended temperature range for the solution heat treatment of X2020 is 950 to 970°F, followed by cold water quenching and aging at 320°F for 10 to 14 hr.

To anneal heat treated material and strain hardened products, the following has been satisfactory: 775°F with a cooling rate of 50°F per hr to 500°F. This procedure is the same as that employed with 2024 alloy, and the normal slow-cooling precautions apply.

An unusual property of the alloy is its slow natural aging. No detectable change takes place in the first 8 hr; after 1 wk the tensile and yield strengths increase about 4000 to 5000 psi each; after one month the strengths increase only 6000 to 7000 psi each; after 9 months tensile strength increases 10,000 psi and yield strength increases about 15,000 psi.

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PHYSICAL PROPERTIES

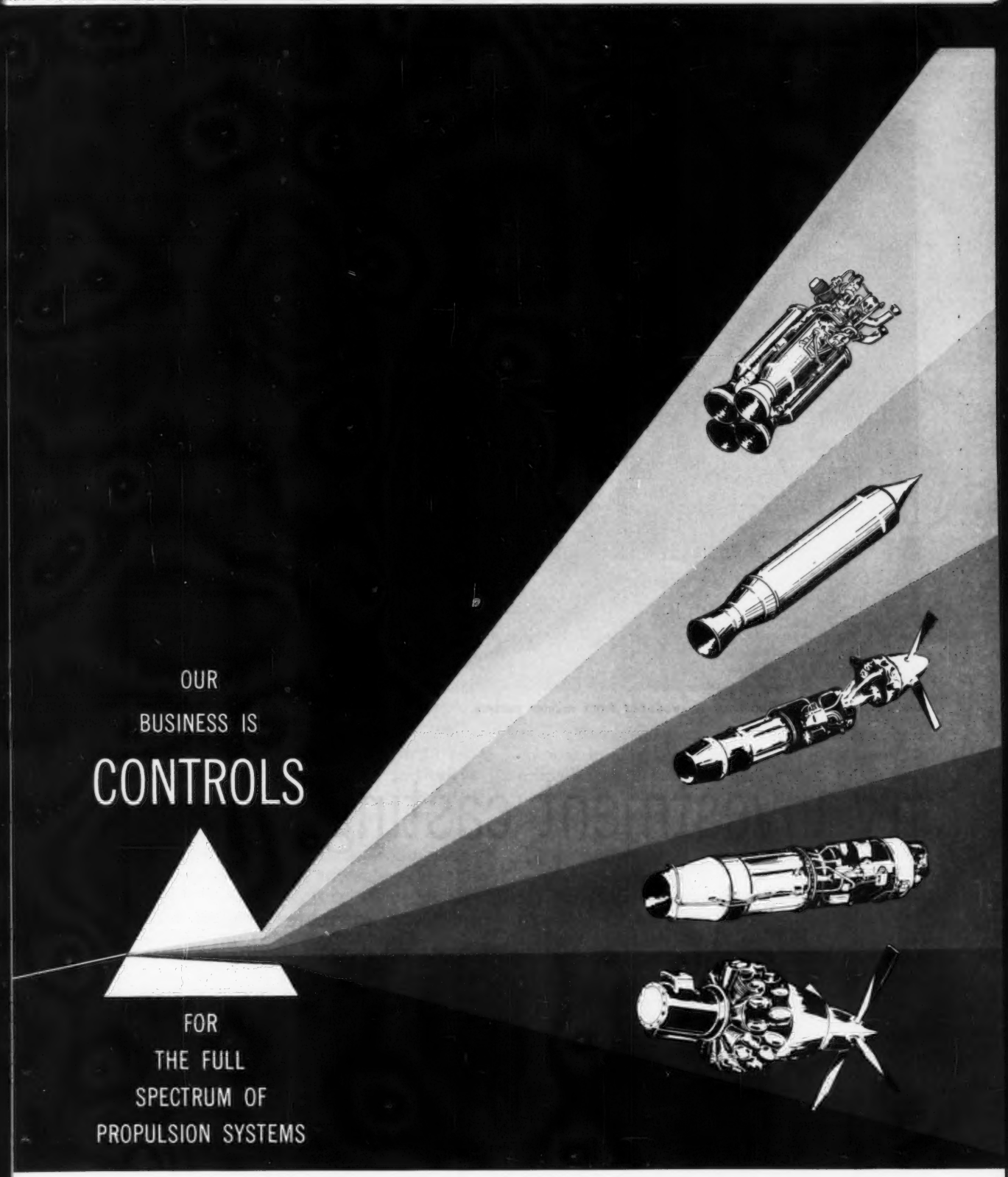
Specific Gravity	**2.71 gr/cc**
Electrical Conductivity at 20° C	
0 temper	26% IACS
T4 temper	21% IACS
T6 temper	21% IACS
Thermal Conductivity at 25° C	
0 temper	0.25 CGS units
T4 temper	0.21 CGS units
T6 temper	0.21 CGS units

Coefficient of Thermal Expansion, per °F x 10^6

Temperature Range	0 temper	T6 temper
32 – 212°F	12.8	12.6
32 – 392°F	13.3	—
32 – 572°F	13.8	—

Comparison of Tensile Properties At Elevated Temperatures X2020-T6 vs. Conventional Alloys

Testing Temp.	X2020-T6 T.S. ksi	X2020-T6 Y.S. ksi	X2020-T6 El. %	2014-T6 T.S. ksi	2014-T6 Y.S. ksi	2014-T6 El. %	2024-T86 T.S. ksi	2024-T86 Y.S. ksi	2024-T86 El. %	7075-T6 T.S. ksi	7075-T6 Y.S. ksi	7075-T6 El. %
75°F	86	79	6	70	60	13	75	70	5	82	72	11
212°F												
½ hr	81	75	9	66	56	13	70	66	6	72	64	15
100 hr	81	75	8	67	57	13	70	66	6	72	64	15
1000 hr	82	75	5	68	60	13	70	66	6	72	65	15
300°F												
½ hr	73	70	8	59	51	13	64	61	7	57	51	20
100 hr	73	70	8	59	54	13	62	59	8	48	45	20
1000 hr	70	68	9	56	51	14	60	57	9	32	29	25
400°F												
½ hr	61	57	7	46	43	13	54	49	10	38	34	20
100 hr	41	37	18	33	29	20	44	40	13	17	15	40
1000 hr	31	27	20	23	18	30	32	29	18	15	13	50
500°F												
½ hr	33	32	12	28	25	18	37	32	14	16	14	35
100 hr	22	20	27	15	12	30	19	16	28	12	9.5	50
1000 hr	19	16	31	12	10	40	15	11	40	11	9	60
600°F												
½ hr	17	16	16	10	9	30	17	14	30	9.5	7	55
100 hr	11	9	35	8	6.5	50	10	7.5	55	8.5	6.5	80
1000 hr	8.5	7.5	38	7	5	60	8.5	6	6.5	8.5	6.5	80



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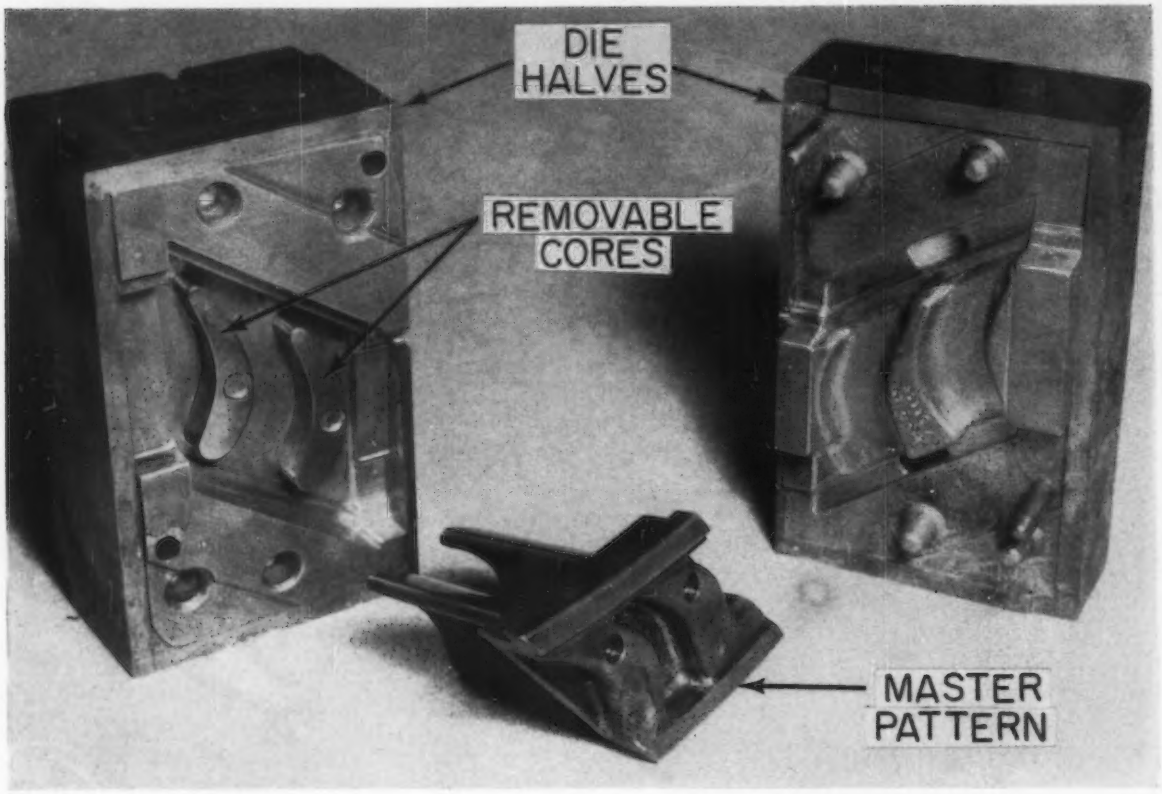


Die assembly (shown opened) is produced from master pattern.

try investment castings

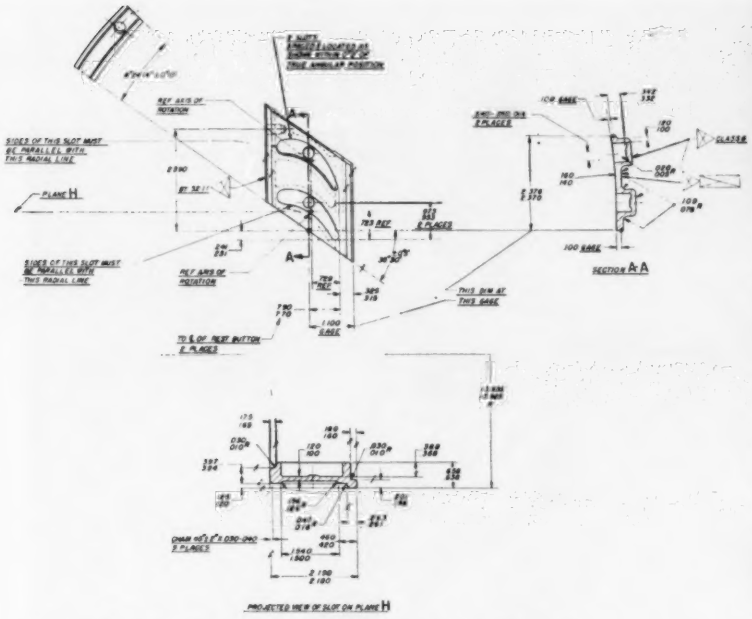
one-piece, intricate shapes allow component design flexibility

by S. Peter Kaprielyan

Following an initial oversell, much like in the early days of titanium, investment castings are now playing a realistic part in modern manufacture. They are not a cure-all but an effective remedy for specific production problems difficult to solve any other way.

Reduction of part through integration, flexibility of design, and elimination of certain secondary operations are the basic advantages of this process.

The operations described in this article represent a typical production sequence from the activities of Arwood Precision Casting Corp. of N. Y. There has been no evidence of a slump here



Design details of Pratt & Whitney J-59 nozzle vane shroud segment produced by Arwood investment casting procedure.

One die assembly can be seen dwelling under wax pot cylinder while a cast wax pattern is about to be extracted from die on table. Extracted wax patterns are placed on contoured racks (in foreground) to maintain critical curvature while curing.

as felt generally in the past few years.

The nature of tooling activities in investment casting still bear the traits of meticulous workmanship of the jewelry trade whence the process originated. However the process is just as applicable to the manufacture of parts weighing several pounds as it is to those of diminutive size. A wide choice of alloys available makes this process well worth investigating from the part of the designer of complex shapes.

Arwood's experience in investment casting comes into play first in the estimating department where initial feasibility studies are made of incoming projects. Here, submitted prints are reviewed in the light of recorded case histories; and decisions are made as to alloys, type of dies, and manufacturing tolerances. Dies for short runs are usually made of Kirksite; steel is used for long runs. Tolerances are considered from two aspects: that of the die, and also of the ultimate casting itself. In some cases tolerances may be held on the die, but the configuration of the part may present an unstable geometry. In such cases design adjustments are suggested.

The next step involves making the master pattern by the tool room. Dies are made in halves, with removable steel-cores for strength and fidelity of reproduction. Die surfaces are finished by grinding.

When soft-metal dies are used, they are encased in steel plates to impart rigidity and to minimize wear. The parting surfaces of encased dies provide effective datum planes for checking of die dimensions.

The wax is usually mixed in 200-lb batches, and is stored within cylindrical containers in a constant-temperature oven. When ready for use, the wax is transferred by air pressure, to a pressure and temperature-controlled vertical ejector cylinder called the "wax pot." The ejection pressure, and the dwelling time of the die under the wax-discharge nozzle are varied, depending upon part configuration.

The wax is now injected into the dies, and the resulting patterns are extracted after cooling. The dies are lubricated after every injection and extraction to ease pattern removal.

If the pattern incorporates a critical configuration, such as the ring-segment curvature in this case, contoured support is provided during overnight storage to allow the pattern to acquire rigidity. After solidifying, the wax patterns are inspected for air entrapment, fins or flash due to improper die clamping or wear, and for contour irregularities. This inspection may range from the simple visual method to an elaborate gaging setup.

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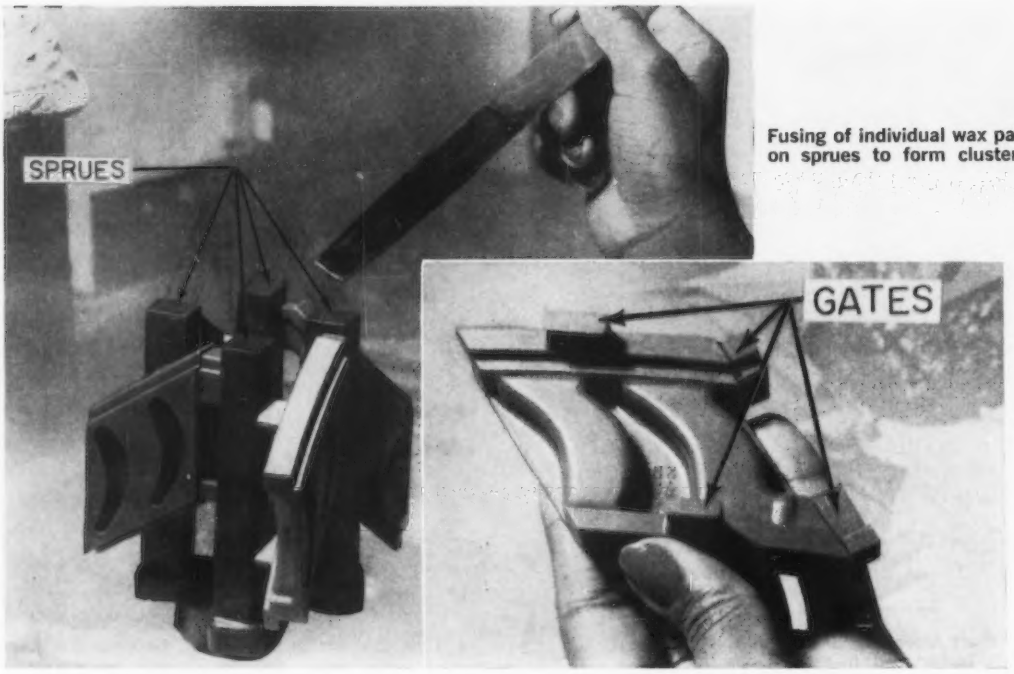

Fusing of individual wax patterns on sprues to form clusters.

try investment castings...

continued

Gating Operation

This consists of mounting a convenient number of wax patterns in clusters, supported by a wax framework called "sprues" or "runners." The individual patterns are seared onto the sprues through "gates" on each pattern. The gating arrangement and the sprue size make-up a key factor in investment casting, because they control the directional solidification of the cast alloy. Metal flow should be so distributed that the farthest area from the gate should solidify first.

To check the integrity of new designs, several samples are cast and submitted to the customer for dimensional and metallurgical analysis. All such initial runs are also subjected to nondestructive testing such as Zyglo, Magnaflux, and/or X-ray. If the quality of the casting proves satisfactory the gating configuration is recorded and frozen for the production run.

Investment Procedure

After assembling the wax patterns in clusters, the clusters are mounted on square, cardboard bases. The bases serve as means for handling the clusters, also provide a bottom closure for the flasks to be used in the next phase. The clusters are now given a dip-coat of ceramic-base slurry which will ultimately determine the quality of the casting surface-finish. The wet, slurry-coated cluster is then held under a fine shower of sand (flint) and rotated for thorough coverage. The sand acts as backing agent for the slurry coat, which is left overnight to dry completely. Next, steel flasks or sleeves are placed around the clusters resting on their bases, to contain the investment. After the flasks are topped by paper collars, they are placed on a vibration table and investment is poured into each flask. The investment consists of a mixture of various sands, water, and a binding agent; the vibration serves to pack the investment in the flasks. Each flask is filled to the level of the paper collar, and evacuated to eliminate air pockets. After allowing the investment to settle, the paper collars are removed, and the upper layer scraped off to get rid of the moist head of the investment. At this stage it is vital to insure a thorough curing of the molds before placing them in the de-waxing oven; otherwise moisture would turn into steam and crack the molds.

De-waxing Process

Flasks are loaded into a low-temperature oven (200-250°F) and baked for about 2½ hours, to extract the bulk of the wax, but a certain amount of hydrocarbon residue remains in the mold. The reclaimed wax is later used to make sprues. This is the phase which gives the process its name—the lost wax process. To burn-off the

Flasks containing wax-pattern clusters (shown in insert) are filled with investment, while flasks are vibrated to promote better packing.

remaining residue the flasks are transferred to a high-temperature oven where the temperature is raised in stages to about 1600°F over a period of 18 to 24 hours.

Casting the Alloy

Near the conclusion of de-waxing, about 120 lbs of alloy is prepared by induction melting, and a test biscuit or bars are cast for lab analyses. Pouring temperatures vary for each job, and they are established during the pre-run tests.

When the pouring temperature is reached, the purged flasks, still at 1600°F, are placed on a vacuum table. Evacuation of flasks during pouring operation facilitates the filling of mold contour intricacies. Following pouring, an exothermic powder is placed on the molten surface to delay solidification of the "head" or "heel" till after that of the casting.

Extraction of Castings

When flasks cool to handling temperature, they are placed under a hydraulic ram to press out the mass of investment and casting. Most of the investment is vibrated free of the casting by holding the heel of the cast cluster against an air hammer. The remaining investment, lodged in recesses, is removed by pickling in caustic soda in the instance of ferrous castings. For non-ferrous castings sand-blasting or vapor-blasting may be used.

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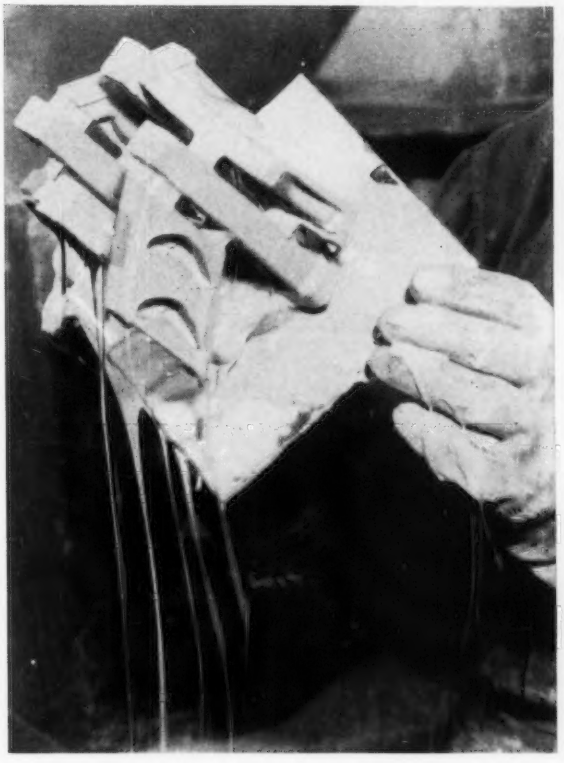
Dip-coating of wax-pattern clusters in ceramic slurry.



try investment castings...

continued

Finishing Operations

After cleaning, the castings are separated from the sprues by high-speed abrasive disks; gates are also ground-off by abrasive belt or wheel. Filing may also be used to dress-off small irregularities. If machining, drilling or reaming are required they also performed at this stage. For this particular part coining is effected to impart curvature. Aircraft-quality castings usually require a final straightening and gaging.

Heat Treatment and Inspection

The part referred to in this case does not require any heat treatment, however in some cases annealing, stress relieving, or tempering may be required. In the event of alloys susceptible to decarburization, a final carburizing treatment may be required. A final sand-blasting prepares the castings for inspection.

After a visual inspection, four gaging operations are performed to check the following features of this part.

1. Contour of coined radius
2. Contour of blade slots
3. Depth of blade slots
4. Overall length of casting

Zyglo and X-ray inspections are also used; magnetic alloys are Maxnafluxed.

In the event test bars are required by the customer, these are pulled by the quality control department and results are logged. Likewise chemical and physical characteristics affidavits are prepared and sent to the customer, together with an approval of dimensions.

In long-run production periodic quality control checks are made to insure consistency of dimensions.

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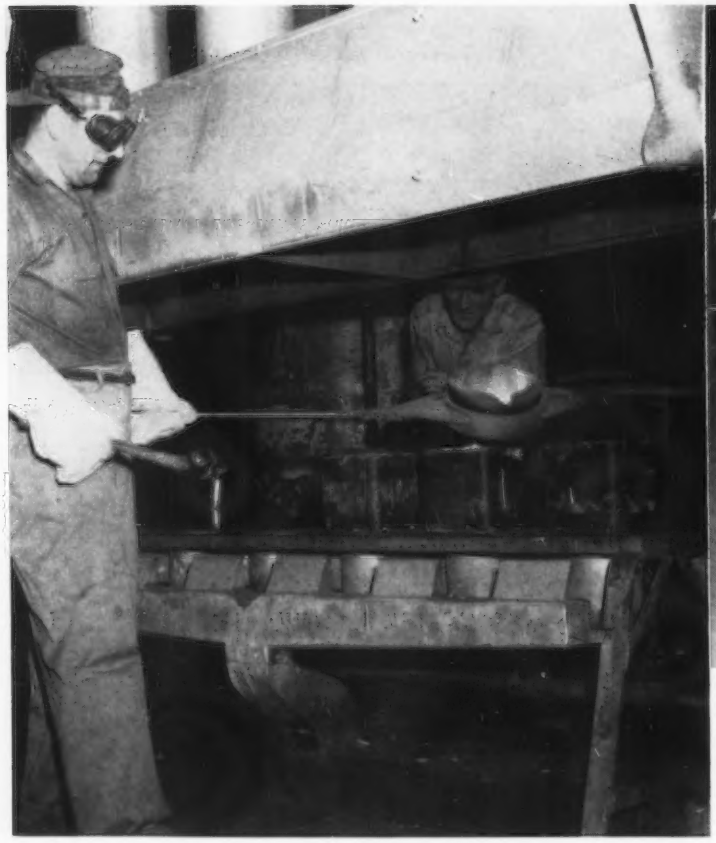
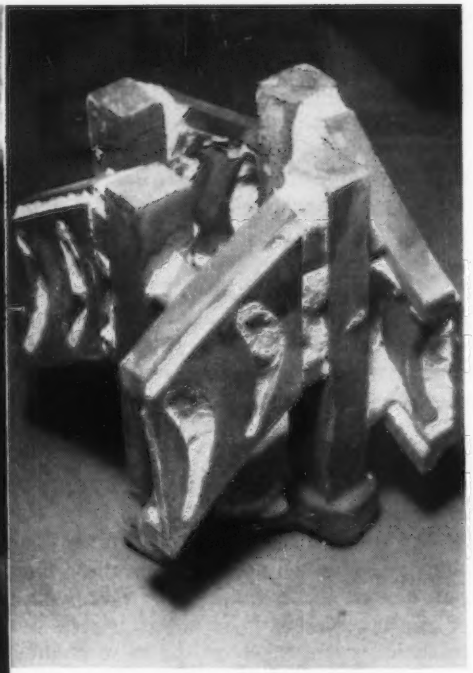
Casting of stainless 310 alloy is accomplished while vacuum is applied from below flasks to insure filling of contour intricacies.





Casting as extracted from flask, prior to pickling in caustic soda solution to remove investment lodged in recesses.

Lindberg-Designed

heat treating installation reduces jet engine parts pickling costs 25% for Jervis

This specially designed annealing and heat treating furnace at Jervis Corporation, Grandville, Michigan, is an interesting example of how cooperation between the user and the maker of heat treating equipment can adopt established furnace principles to the improvement of production methods. Jervis and Lindberg engineers, starting with a conventional box type furnace, designed this furnace with two chambers, one for preheat and one for high heat, and added a third with a water jacket for protective cooling. This combination provides efficient heat equalization, protective atmosphere, and protects against corrosion and carbide precipitation. Jervis estimates this furnace provides a 25% reduction in pickling costs, as well as improved quality, in the treating of jet engine parts.

Lindberg equipment and Lindberg planning can help you find the most effective answer to any problem of applying heat to industry. We cover the field, heat treating, melting and holding, tempering, brazing, enameling furnaces, ceramic kilns, high frequency units, and are in the ideal position to recommend just the type of equipment most suitable for your needs. This can be factory built or field-installed in your own plant, fuel-fired or electric. Consult your local Lindberg Field Representative (see the classified phone book) or get in touch with us direct. Lindberg Engineering Company, 2473 West Hubbard Street, Chicago 12, Illinois. Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California.

The handsome Jervis plant at Grandville, Michigan occupies 238,300 square feet of floor space.

Mr. James Bockheim, Metallurgist at Jervis, says, "We can handle any aircraft material in this furnace . . . and operate it with just one man."

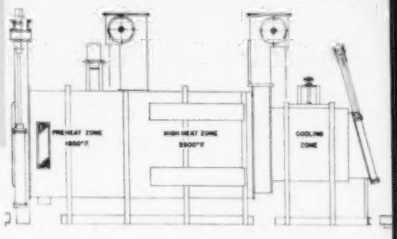
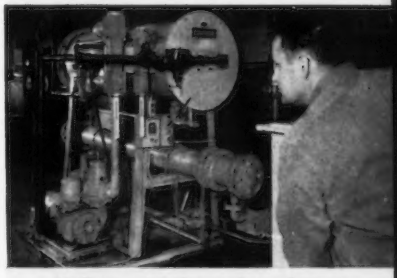


Diagram shows the unusual three-chamber furnace design.

Work coming from the cooling chamber after treatment.



Lindberg generator produces furnace atmosphere exothermically from natural gas.

LINDBERG heat for industry

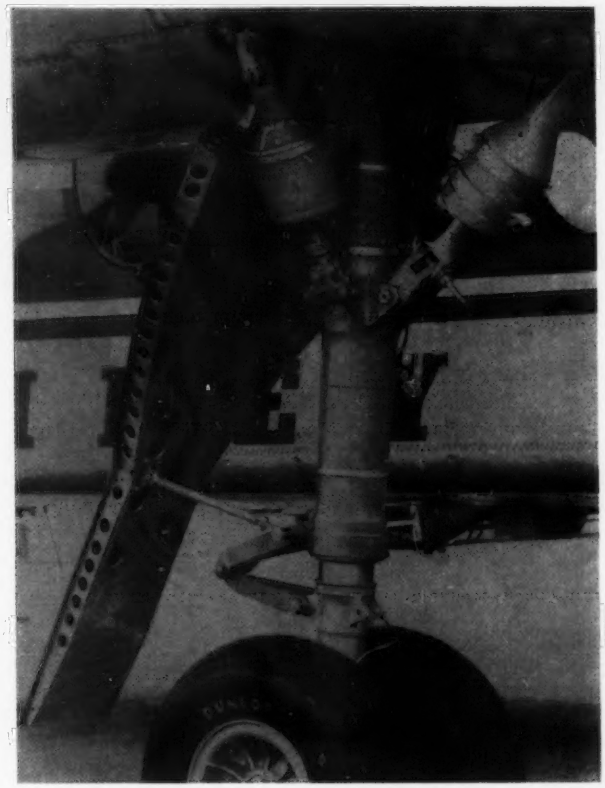
Circle 141 on Inquiry Card, page 81

FARNBOROUGH 1958

Farnborough 1958

by Ronald A. Cole

"Flying Crane" version of 33,000-lb Westland Westminster, powered by two Napier Eland turbines. Main and tail rotors are same as on the Sikorsky S-56.



Fairey Rotodyne landing gear incorporates ground resonance dampers with adjustable feature.

Helicopters dominated this year's Society of British Aircraft Constructors Show, the annual trade fair of the British aircraft industry. Active displays in the rotary wing class included the Westland Westminster and Fairey Rotodyne, each weighing about 33,000 lb.

Using the same five blade rotor as the Sikorsky S-56 but with a different type of power plant, the Westminster can hoist 6½ tons. Power is provided by two Napier Eland engines, each producing 3650 hp. Each unit drives from the rear via an override clutch, a shaft with flexible couplings and Sinclair hydraulic clutches. These clutches incorporate two sets of impeller bucket wheels in tandem, and allow a maximum of 2 per cent slip to correct asymmetry of power. Pilot controls are conventional cyclic and collective pitch sticks. Engine speed is governed through a speed-selection lever which eliminates the need for manual throttle-pitch coordination. Power control has therefore been removed from the collective-pitch lever, and it is only necessary to select a speed setting for the anticipated flight case. Additional power, if required, is automatically made available at that speed setting. This constant-speed arrangement allows the pilot to concentrate on flying. In the event of one engine failure, the other produces maximum power.

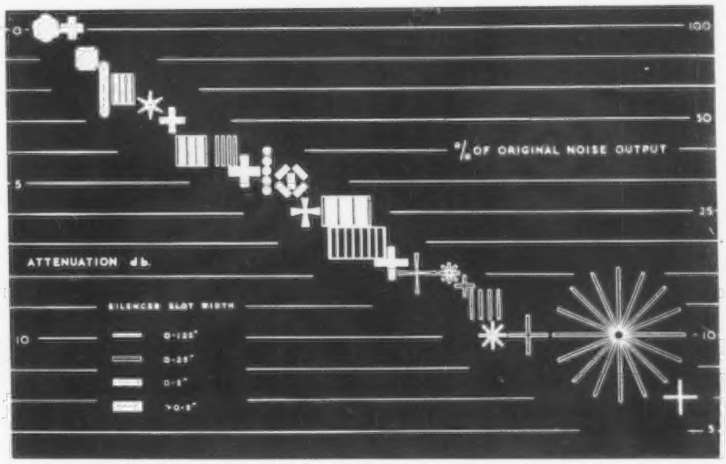
Rotodyne

The Fairey Rotodyne (AMM, May 1958), surprised everyone with its high speed runs, and its VTO capabilities, with all lift being produced by the powered rotor. Progress has been made in reducing noise.

A new feature shown was the method of attaching main landing gear to the airframe. Each oleo strut is able to pivot about its attachment point, with movement restricted by three dampers forming an inverted tripod.

Each damper unit consists of a short cylinder enclosing a rubber cushion to provide resistance to a plunger. By adjusting the stiffness of each cylinder dangerous ground resonance is controlled.

continued on next page



Results of noise suppression tests with various nozzle shapes and slot widths conducted for the Fairey Rotodyne.

Farnborough 1958 . . . continued

Wessex

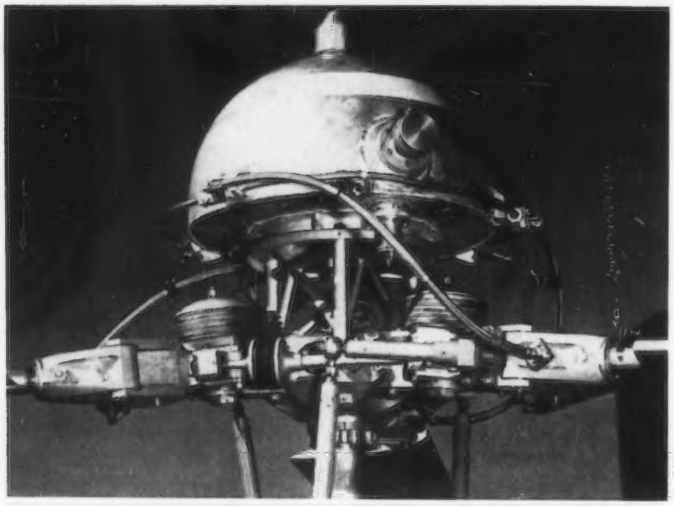
Another development was seen in the Westland Wessex helicopter which has been derived from the Sikosky S-58 by substituting a Napier Gazelle turbine for the Wright Cyclone engine. This turbine, developed specially for helicopters, can be mounted at any angle to suit the particular installation. Because of the free turbine disc feature, it is possible to do without the usual clutch in the rotor drive. Elimination of this and the lesser weight of the Gazelle have given the Wessex a slightly better performance.

A flight demonstration was also given of the 18,000-lb tandem-rotor Bristol 192. A Gazelle turbine is mounted beneath each rotor, and there is a drive connection between the two heads. In the event of one engine failure, both rotors remain powered. It is possible to take off and fly on one engine; this was demonstrated by blanking off the intake to one engine during the flying display. Gazelle produces 920 hp under normal conditions, but can be pushed up to 1300 hp for one hour, or 1650 hp for 2½ min. As on the Wessex the free-turbine principle is employed to eliminate clutches.

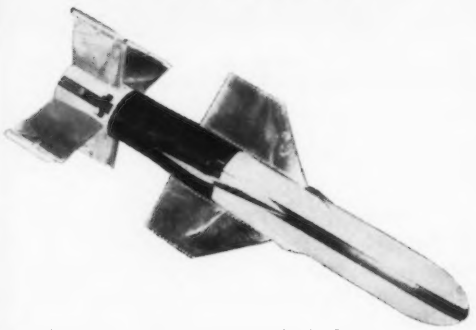
Light Helicopters

The Saunders P. 531 was also shown. This is a development of the smaller Skeeter helicopter (AMM, July 1958), and comes in the five-seat

Rotor head of a Saunders-Roe Skeeter, fitted with the Napier rocket booster system. This system compensates for performance lost through altitude, heat or humidity. Thrust is generated at rotor tips by converting high-test peroxide into free oxygen and super-heated steam. Discharge is from low-pressure high-velocity jet nozzles.



The Short SXA-5 development missile for close shipborne air defense. It is propelled by a solid-fuel rocket.



Fairey Ultra-Lite helicopter to be used for sub-spotting. Directional control is obtained by operating rudder in turbine exhaust.

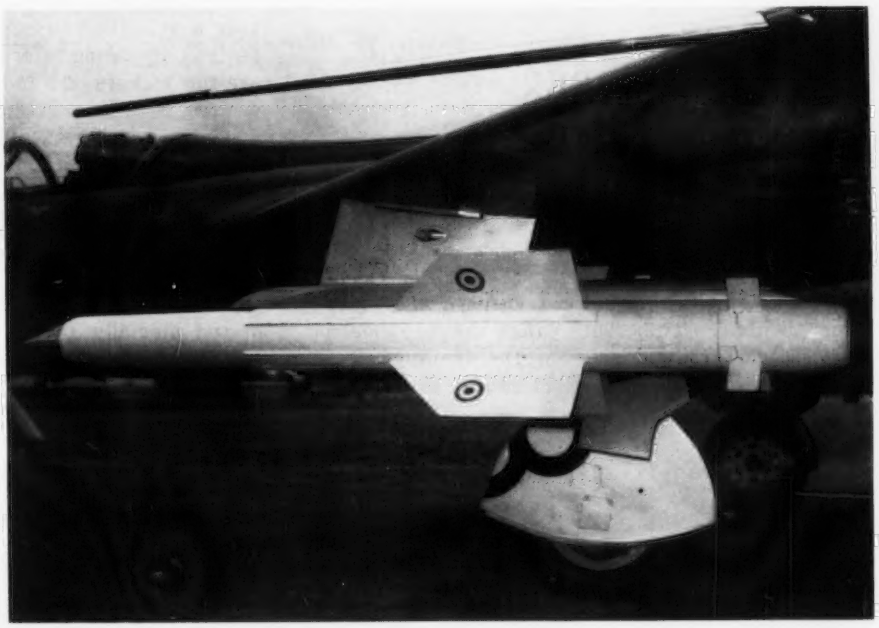
The Armstrong Whitworth Seaslug on its launcher. This ship-to-air missile is being installed on new rocket cruisers being built for the Royal Navy.

personal-transport class. Power is supplied by the free-disc Blackburn turbo turbine of 425 shp. Drive is taken from the free disc, out the rear of the engine, via a reduction gear and then onto a shaft running forward under the engine. This drives a crown wheel at the base of the rotor spindle. Maximum rotor speed is 360 rpm; engine speed is 32,000 rpm. A full-authority governor controls the turbine and therefore the rotor-speed, as in the Westminster. Should the governor fail, the twist grip on the collective stick is used as a throttle to by-pass the governor.

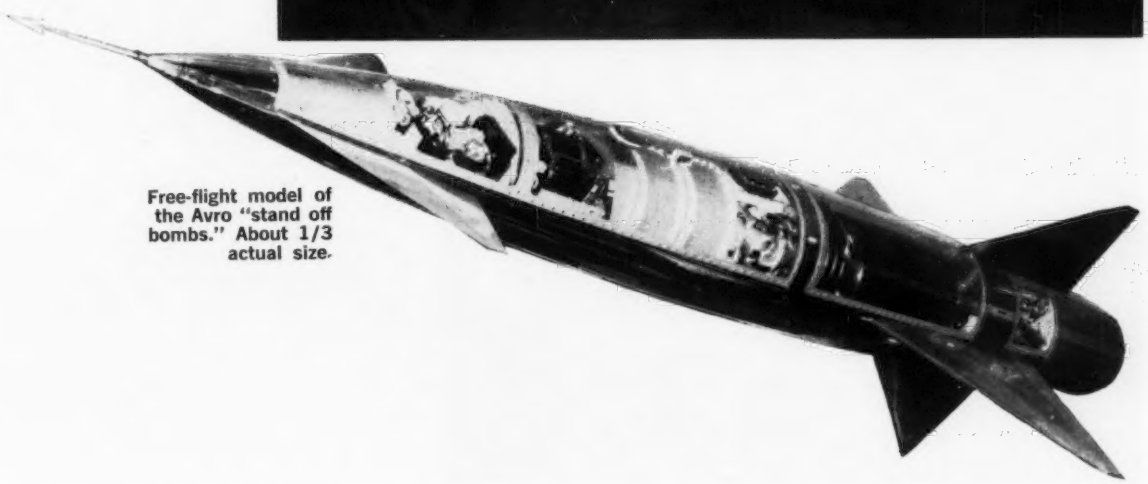
Soon to be adopted for shipboard use as a sub spotter the diminutive Fairey Ultra-Lite helicopter was also demonstrated. A Blackburn Palouste turbine air-generator supplies compressed air to burners at the rotor tips where fuel is added and burned. Directional control and torque reaction is obtained without any loss of power by placing a vertical rudder in the exhaust of the turbine. All-up weight is 1800 lb.

Missiles

Missiles and associated equipment on show told of a quickly developing industry capable of taking advanced projects in its stride. The Blue Streak missile is a typical example incorporating the combined efforts of several prominent groups, including Sperry, General Electric, Rolls-Royce and de Havilland. Little is known except that it is an IRBM. Mention of the Black Knight indicated it was a research vehicle to investigate the re-entry problems posed by Blue Streak. Recently there has been talk of modifying the Black Knight design to place a satellite in orbit. The biggest tangible attraction was offered by models



Close up of the de Havilland Firestreak infrared homing missile, mounted on a Hawker Hunter. The carrying rack has means to keep missile warm in flight. Solid-fuel propellant is used. Control is effected through four movable vanes about combustion chamber.



Free-flight model of the Avro "stand off bombs." About 1/3 actual size.

The Pye P.V. short-range missile for use against tanks and fortified emplacements. This portable missile is five ft long and has a span of two ft. Boost and sustainer motors use solid fuel. Guidance is through thin wires trailing behind missile. Optical sight and thumb-operated control are used to keep missile on target.

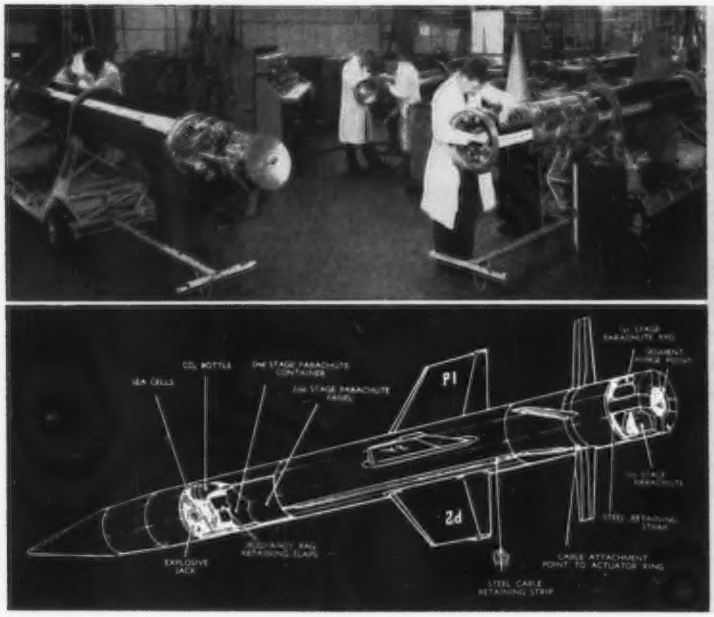
Farnborough 1958 . . . continued

of the Avro "stand off bomb" and the full-scale mockup which was flown slung beneath a Vulcan bomber. The writer estimated the bomb to be about 35 ft long. Notable features are the delta noseplate of the canard type which pivots about trunnions at the mid chord position for longitudinal control. The rear wings have inboard-mounted control surfaces on the trailing edge; only the upper fin has a small rudder at its base. It is thought that the full size weapon is powered by liquid-fuel rockets, possibly two de Havilland Spectre units.

Examples of both the English Electric Thunderbird and Bristol Bloodhound ground-to-air missiles were shown on their ramps and carriers. There is no let up in the propulsion battle between these two firms. Bristol employs two Thor ramjets on its missile and claims that this gives maximum range for a given weight. English Electric claims that by using a solid fuel advantage may be gained by replacing some of the carbon atoms by those of light metals. It is reported that the Bloodhound and its detection system has proved so effective that it is being developed into an anti-missile missile.

Missiles shown included a version of the Short GPV, a general purpose development missile. New ideas and tests are carried out on this vehicle which is fired out to sea and recovered.

Anti-tank missiles for use by infantry provide a relatively untapped market; two similar designs are being offered by British firms. These are the Vickers 891 and the Pye PV. The Vickers weapon is the more compact, and it can be carried and operated by one man. In both cases the operator uses an optical sight attached to a small hand controller with a column. Signals pass along thin wires trailing behind the weapon. The control loop is such that accuracy improves as the missile approaches its target. Perhaps the last word on this subject will be uttered by Fairey, stated officially to be working on an anti-tank missile that may well sweep the heavy tank from future battlefields.



Configuration drawing of GPV missile with a proved recovery system. This workhorse vehicle is fired over water to test new design concepts, and retrieved. GPV missiles built at Belfast by Shorts is shown (above) at the works of Elliott Bros. Ltd. (London), where the homing equipment is installed.

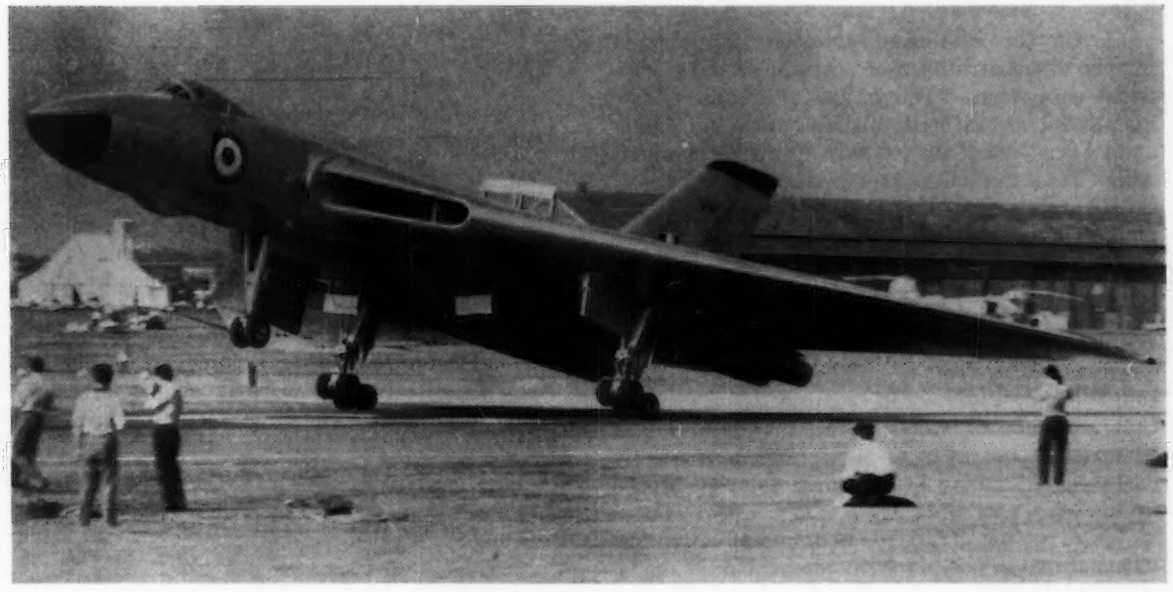
The Blackburn NA. 39 supersonic low-level bomber designed for shipboard operation. Both wings and tail surfaces are blown with air tapped from the two Gyron Junior turbines. Tail cone opens out to form air brake.

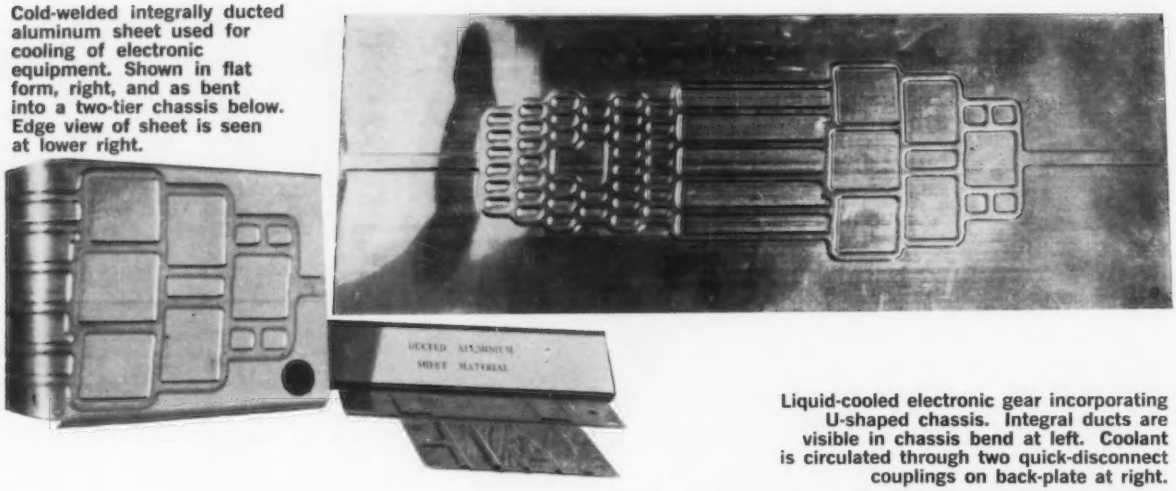
Many applications of fiber glass to the missile field were seen in the static exhibition. An interesting application claimed was the use of polyester-resin impregnated fiber-glass vessels for air-pressure storage. Another application involved fiber-glass nests for small rockets carried on fighters either externally or internally. Advantages claimed include manufacturing economy and good storage life.

High Performance Aircraft

The Blackburn NA. 39 supersonic low-level bomber flew past at a very slow speed with flaps and air brakes extended. This machine has a three stage sweep on each wing giving the crescent planform for which the Handley Page Victor is famous. The reason for lessening the sweep towards the tips is that over the inner span t/c ratio is high, and most sweep is needed here to

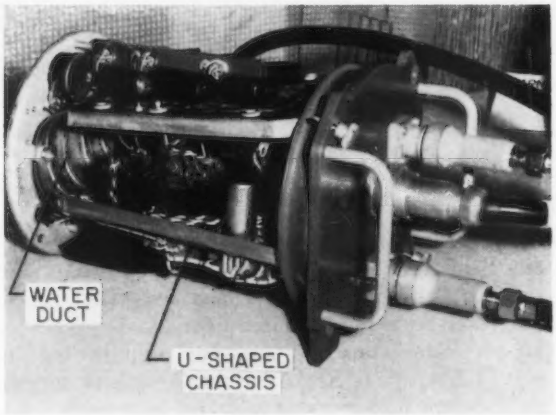
Avro Vulcan effecting touch down. Note extended dorsal and ventral air brakes.





Cold-welded integrally ducted aluminum sheet used for cooling of electronic equipment. Shown in flat form, right, and as bent into a two-tier chassis below. Edge view of sheet is seen at lower right.

Liquid-cooled electronic gear incorporating U-shaped chassis. Integral ducts are visible in chassis bend at left. Coolant is circulated through two quick-disconnect couplings on back-plate at right.



Farnborough 1958 . . . continued

delay compressibility effects. Over the outer panels, with lesser thickness, sweep plays a less important part.

A highlight of the flying show as a demonstration of "lob" bombing techniques by the crescent-wing Victor and delta-wing Vulcan bombers. It was spectacular to see such large aircraft roll off the top of a half loop. Both have a span of 110 ft and an aggregate thrust of about 68,000 lb.

A development version of the Comet demonstrated short landing techniques with the aid of thrust reversers on the Avon engines.

Accessory Equipment

On the equipment side, the Ministry of Supply demonstrated new ways of cooling electrical equipment through use of liquids. With high-speed aircraft the air stream is no longer available as a heat sink. Study of present methods which use a fan-induced air-blast shows that they constitute an unnecessary waste of power, space, and weight. Following a test programme the M.O.S. now advocates the use of liquid cooling for radio and other electrical equipment. Suggested media include fuel, water, and Montasil "E," a synthetic fluid which remains usable over the temperature range from —85°F to +400°F. As a rough example of power economy it was stated that a trickle of water would maintain a unit dissipating 200 watts at 30°C (86°F); a poorly-designed air-cooling system may take 50 to 100 hp to do the same job.

A cooling arrangement found effective has incorporated a chassis with integral fluid ducts, These ducts are planned to run so that fluid gets to the immediate base area of each hot component. The heat-transfer path is down the body of the part to its base and then to the fluid. One type of chassis uses 'Kynal" roll-welded heat transfer plates. These consist of two sheets of aluminum alloy cold-welded together by pressure rolling. The welding is interrupted where a pattern has been printed on one of the sheets using a "stop weld" ink. Fluid under a pressure of 1000 psi is then forced between the sheets where they are not combined, and this forces them open to form a pattern of integral tubes. Suitable end-connections are then made to couple with feed lines, and the plate is ready to take the radio parts.

All trace of the ink evaporates when the sheets are annealed after welding. If needed, the sheet can be bent to various shapes after the tubes have been formed. A technique presently under development will allow the integral tubes to be formed on one side of the sheet only, leaving the other side flat. This may be advantageous in some applications.

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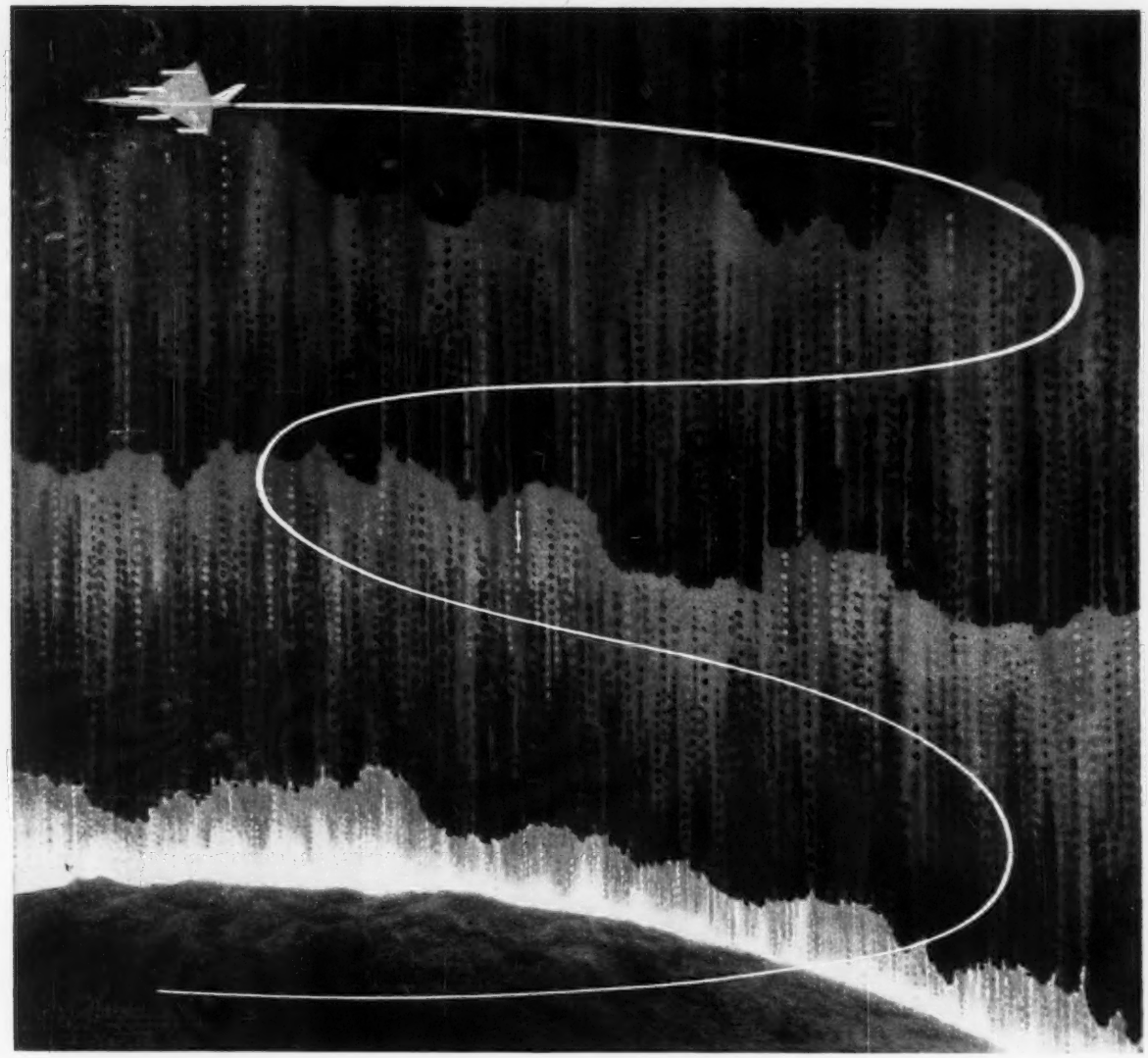


New extreme-high-temperature lubricants for missiles and supersonic aircraft **SHELL ETR GREASES**

One of the serious lubricating problems faced by designers of missiles and supersonic aircraft has been solved by scientists at Shell Research Laboratories.

The problem: to find a grease which would permit components to operate with certainty under extreme high temperatures. Co-operation with representatives of bearing manufacturers and military personnel resulted in a completely new class of greases—SHELL ETR GREASES.

These greases can easily withstand temperatures up to 600°F. They give superior lubricating performance because of a special thickener—an organic vat dye—which has exceptional heat stability and jelling efficiency.

If you are presently in the market for an ultra-high-temperature-range grease, we will be glad to provide more information on Shell ETR Greases.

SHELL OIL COMPANY

50 West 50th Street, New York 20, N.Y.
100 Bush Street, San Francisco 6, Calif.

SHELL

AIRCRAFT & MISSILES MANUFACTURING DIGEST OF RECENTLY PUBLISHED TECHNICAL MATERIAL

DESIGN

BRITISH ROCKET AND RAMJET ENGINES. A. D. Baxter and S. W. Greenwood. *Acft. Eng.*, (September 1958). 17 pp. A survey of work to date given with representative design and performance criteria.

GUIDANCE FOR THE SPACE AGE. C. J. Mundo and E. W. Tooher. *Aero Sp. Eng.*, (September 1958). 4 pp. A review of space guidance in the light of some problems to be encountered.

THERMAL STRESSES IN DESIGN. S. S. Manson. *Mach. Des.*, (September 4, 1958). 8 pp. Interpretation given of fatigue data for ductile materials.

OLD PROBLEMS FOR BIG SOLID ROCKETS. C. D. McKinney and L. E. Morey. *Astro.*, (September 1958). 4 pp. Design, production, and performance considerations presented.

SOME NOTES ON PRESSURE-CABIN DESIGN. P. B. Walker. *Acft. Eng.*, (September 1958). 5 pp. Consideration of detail design in the light of recently acquired knowledge.

MATERIALS AND PROCESSES

FOUND . . . A LOW-ALLOY STEEL FOR MISSILES. W. M. Stocker, Jr. *Amer. Mach.*, (August 25, 1958). 2 pp. Discussion of workability characteristics, physical properties and applications of Airsteel X-200 alloy, air hardenable to 280,000 psi.

SPECIAL REPORT ON HK-31. *Des. News*, (September 1, 1958). 2 pp. Properties, compositions, workability, and applications for this widely used magnesium alloy.

ISP: HOW HIGH FOR CHEMICAL FUELS? James Carter, *Astro.*, (September 1958). 5 pp. The importance of high specific impulse, some of the possibilities and limiting factors of the foreseeable chemical fuels.

HIGH-PERFORMANCE STEELS. E. A. Loria. *Mach. Des.*, (September 4, 1958). 5 pp. Criteria given for the selection of steels for specific design applications.

SPACE-AGE METALS FORMED UNDER WATER BY EXPLOSION. *Des. News*, (September 5, 1958). 1 p. Brief description of how titanium, Vascojet 1000, AMS 6434, and mild steel are formed with dynamite and C4 explosive composition.

TITANIUM GETS GLASS COAT. *Amer. Mach.*, (August 25, 1958). 1 p. Boeing method uses water-soluble glass coating, sprayed prior to heat-treating, as protection against contamination.

COLD PROPELLANTS FOR HOT PERFORMANCE. John L. Sloop. *Astro.*, (September 1958). 6 pp. Cyrogenic liquids show great performance potential. Problems to some seem insurmountable. This article looks at the possibilities.

PRODUCTION

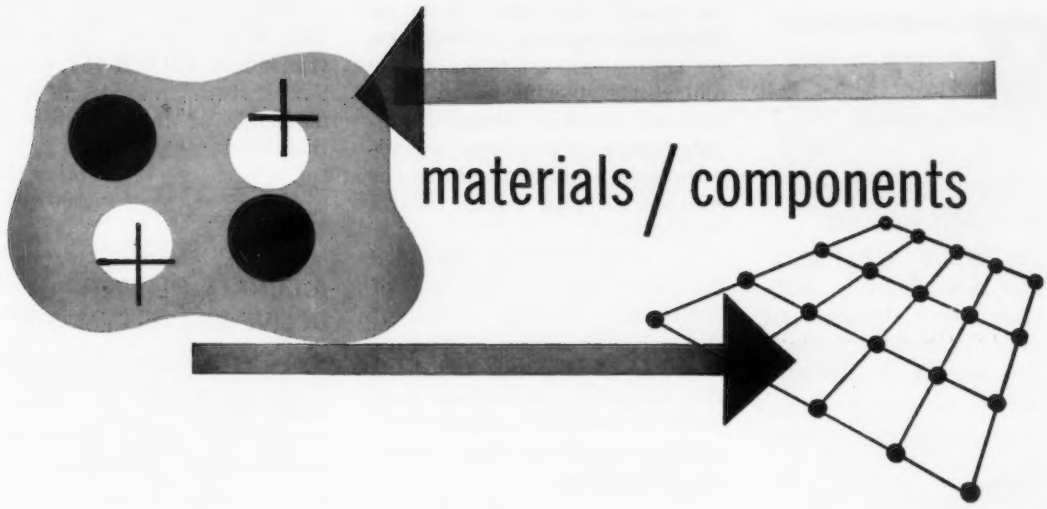
HOW EASILY CAN HONEYCOMB STRUCTURES BE MACHINED? R. G. Kellner. *Mach.*, (September 1958). 6 pp. Techniques and tools described for slicing, milling, sawing and cutting of holes as practiced at the jet engine department, aircraft gas turbine division of General Electric Co.

TOOLING AND TECHNIQUE BUILD 880 JETS. G. H. DeGroat. *Amer. Mach.*, (August 25, 1958). 5 pp. Specialized manufacturing equipment and methods described as used in production of Convair commercial jet transport.

REVIEWED IN THIS ISSUE

Periodicals and Papers

Aero Sp. Eng. Aero Space Engineering
Acft. Eng. Aircraft Engineering (British)
Amer. Mach. American Machinist
Astro. Astronautics
Des. News. Design News
Iron Age. Iron Age
Mach. Machine
Mach. Des. Machine Design
Tool Engr. Tool Engineer



SMALL SPEED CHANGERS OFFER IMPROVEMENTS

Metron's new miniature speed changers—Series 8—are an improved version of the dependable Series 6 units now used in military, laboratory and O.E.M. applications.

Black anodized aluminum cases have size 11 servo-mounts. Several other types of attachable mounts are available.

Input and output shafts run in double heavy-duty ball bearings. Countershafts run in special sintered iron and copper bearings that are self lubricated. Precisely hobbed, smooth-running spur gears are 96 pitch and 20° pressure angle. MIL-G-3278 grease lubricates the gears.

Metron Inst. Co.

Circle 176 on postcard for more data

PRESSURE SWITCH HAS WIDE RANGE

A pressure switch designated Model 3078 is designed for use with fuel, water-alcohol mixtures, hydraulic, pneumatic, and engine oil systems.

Switch has a pressure sensing range from 5 to 400 psig and a proof pressure to 500 psig. Its temperature range is from —65 to 275°F. Electrical rating is 10.0 amp resistive at 14 to 30 v dc.

The unit is pre-set, safety-wired and sealed at the factory. User, however, by breaking the seal can adjust the actuation point over the full system pressure range, without the use of special tools.

Frebank Co.

Circle 177 on postcard for more data

ALUMINUM ASBESTOS JACKET PROTECTS FROM MISSILE BLAST

Aluminized reflective asbestos fiber withstands 2000°F continuously, 3000°F intermittently. Thermazip is closed by a plastic or metal zipper track stitched to the fiber with high temperature Teflon thread. An external flap is supplied to protect the track and provide a neat jacket.

Used as a protective cover over valuable cables and components, Thermazip eliminates damage from high temperature exposure to missile blasts and engine or rocket heat.

It is available in I.D.'s from $\frac{3}{8}$ in. up to increments of $\frac{1}{8}$ in.

The Zippertubing Co.

Circle 173 on postcard for more data

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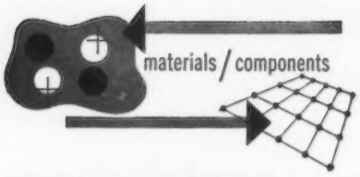


INSTRUMENT DRYER IS SELF-REACTIVATING

The Model A10 instrument dryer is a miniature, self-reactivating dryer designed to replace static (non-reactivating) instrument dryers in airborne applications.

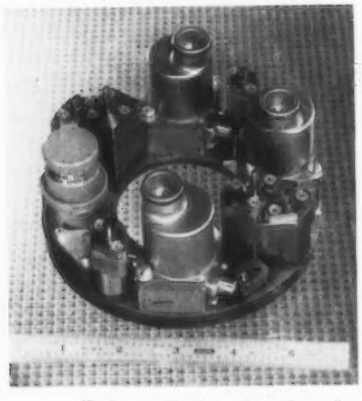
Available in three capacity ranges, the Model A-10 dryer conditions ½, 1, and 1½ cu ft of air. It functions in any position and can be supplied for easy adaptation to existing mountings.

Power requirements are 28 or 115 volts AC or DC. 35, 50, 65, watts, depending on capacity.

Daco Instrument Co.

Circle 172 on postcard for more data

MISSILE CONTROL UNIT USES PRINTED CIRCUIT IN HYDRAULIC SYSTEM



Prime factor in the design of a new electro hydraulic steering control system is simplicity.

The system is adaptable to control the positioning of steering surfaces, jet-avators, jet engine exhaust areas, nozzle and vector steering controls. It converts low-level electronic signals from a missile's main guidance system into hydraulic forces which actuate directional control mechanisms.

A feature of its simplified design concept is the use of "hydraulic printed circuits," analogous to electrical printed circuits. It combines manifolds and mounting structures in a series of integral passageways, eliminating all external plumbing and leakage.

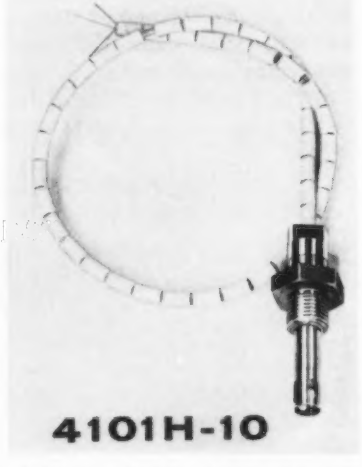
Garrett Corp.

Circle 170 on postcard for more data

TEMP TRANSDUCERS HAVE RAPID RESPONSE

A new line of 100-ohm-resistance, 200-millisecond-response transducers permit accurate measurement of transient temperatures encountered in missile and aircraft applications.

Rapid response results from type of resistive sensing element used. It is a deposited-



platinum film having extremely low thermal mass.

The fluid-immersion transducer (4101L-11) is LOX compatible. It is available in two calibration ranges: —300F to —290F and —320F to +500F.

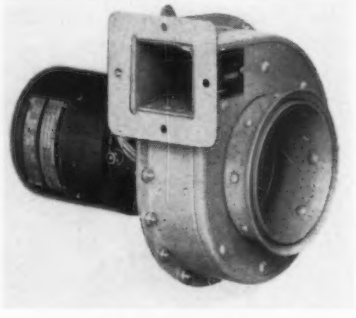
The air transducer (4101H-10) operates in static to high velocity gases. The surface transducer (2101H-15) permits temperature measurement on materials of limited area and thickness.

Arnoux Corp.

Circle 179 on postcard for more data

AIRCRAFT BLOWER DELIVERS 175 CFM AIR

The MSA 7861 aircraft blower unit is designed for airborne operation at high speeds, and against high pressures. The unit delivers 175 cfm of air against an operating pressure of 16 in. of water and can be used in a temperature range from —75 to 160°F.



The totally enclosed, explosion-proof, 1.2 hp aircraft motor furnished with the unit operates at speeds up to 11,000 rpm. The MSA 7861 unit weighs 8 lb.

Torrington Mfg. Co.

Circle 168 on postcard for more data

SAVINGS CLAIMED FOR ALUMINUM ALLOY

Reduced weight of aluminum parts by 25 to 40 percent is claimed for new aluminum casting alloy called "Tens-50." Castings can be specified instead of forgings in many cases.

The alloy is designed to permit the average foundry to attain design minimum, which are: permanent mold-45,000 psi; and casting-42,000 psi.

Navan Products, Inc.

Circle 167 on postcard for more data

NEW DRILL BUSHING FOR PLASTIC TOOLING

The American "Redskin" in drill bushings for plastic tooling eliminates the problem of spin-out due to over heating.

Drill bushing consists of a precision bushing molded into special plastic by Rezolin. This balanced combination carries away frictional heat before it can destroy the bond between bushings and plastic fixture.

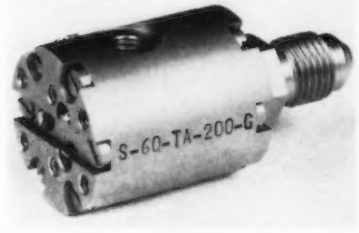
Using this new drill bushing in plastic tooling, will save on costly jigs, reduce parts spoilage, and provide permanent proof of careless working habits, according to manufacturer.

American Drill Bushing Co.

Circle 171 on postcard for more data

DIAPHRAGM TRANSDUCER HAS 0-5000 PSI RANGE

A miniature, single coil, variable reluctance, diaphragm type transducer is available for



use as the variable inductor in standard inductance and reactance controlled AM/FM subcarrier oscillator systems. Differential, gage and absolute models are offered with a wide selection of pressure ranges between 0-10 psi and 0-5000 psi.

Ultradyne Inc.

Circle 178 on postcard for more data

RACK-PANEL CONNECTORS MATE WITHOUT GUIDES

Deutsch rack-and-panel connectors mate without guidepins or stop-ins. In the new DM 6502-3719 P/S rack-and-panel plug, six coax contacts and thirteen #20 contacts are provided in a miniature shell. Coax contacts accept RG-196/U cable.

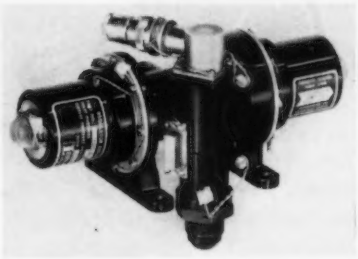
The mated connector is environmentally-sealed, vibration-dampened, largely unaffected by pressure variations and mates accurately when mounted within commercial tolerances. Deutsch rack-and-panel plugs meet applicable AN "E" requirements and the latest revision of MIL-C-5015 requirements for service A voltage rating.

The Deutsch Co.

Circle 169 on postcard for more data

PNEUMATIC REGULATOR HAS 2-STAGE OPERATION

A new lightweight two-stage pneumatic regulator embodies a multi-poppet feature to insure close regulation of outlet pressures over a wide range of inlet pressures. Designed for pressurization of instrument air bearings on missiles, the new regulator will maintain an adjustable outlet pressure of between 50 and 30 psig within



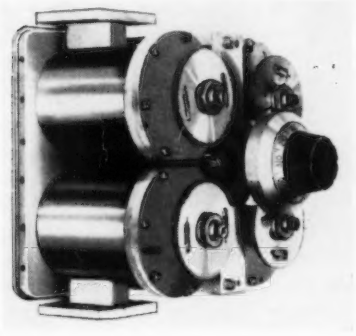
plus-minus 0.2 psi at inlet pressures varying between 3000 and 300 psig. Flow rates under these conditions are 8 to 20 scfm of air or nitrogen.

Wallace O. Leonard Inc.

Circle 175 on postcard for more data

GANG-TUNED RADAR HAS SINGLE-KNOB TUNING

A multi-element single-knob tunable filter for interference reduction and spectrum control in radar systems offers high selectivity and precise



gang-tuning of its four sections. The maximally flat design utilizes quarter-wave aperture couplings between cylindrical Invar cavities. These cavities are operated in the low-loss circular TE_{011} mode, with non-contacting choke-type plungers as tuning elements. Although suited to low power use, the design can be modified to handle high peak powers as a spectrum limiting filter.

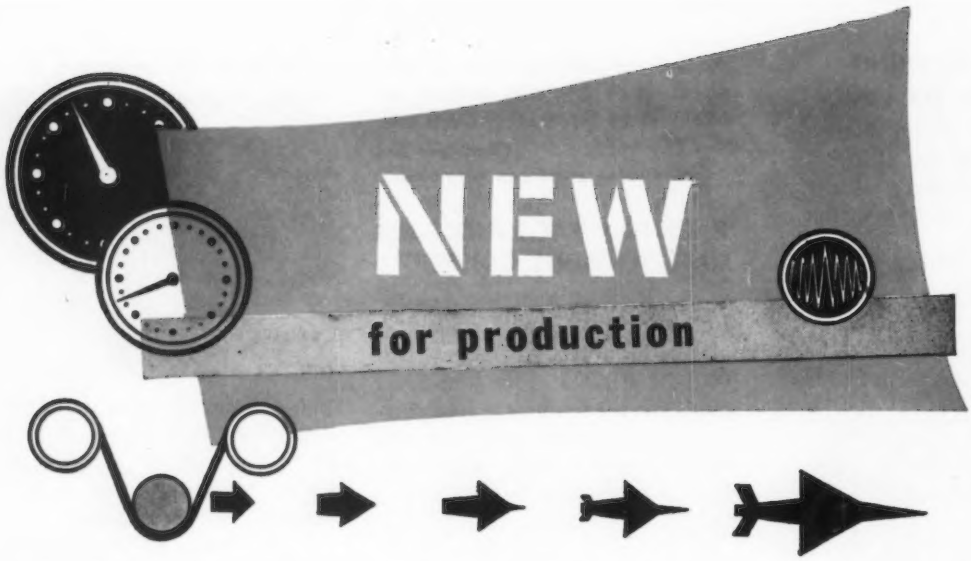
Backlash is prevented by spring-loaded split gears, and micrometer-type drivers aid in high speed tracking.

Airtron, Inc.

Circle 174 on postcard for more data

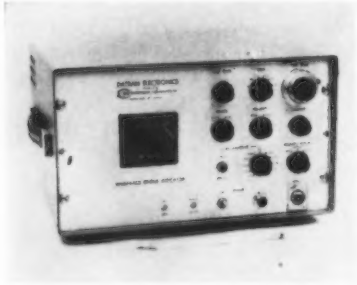
more efficient than any now in

assembled from six basic, off-



STRAIN GAGES MEASURED

Self-balancing instrument for calibration or measurement of strain gages, strain gage type



transducers, and other resistance instruments reads actual valves such as psi, microinches per inch, foot pounds. It automatically handles both positive and negative input signals to indicate values from —1000 to +1000.

Front panel controls permit eight settings for strain gage problems.

Instrument is known as Datran R31 (Resistance Bridge Indicator).

Calibration selector switch enables an operator to shunt any one of the 4 possible bridge legs with a choice of 5 precision calibration resistors.

An adjustable DC bridge power supply is included in the instrument circuitry. This circuitry includes dual gaged precision potentiometers which are driven by the servo motor until the amount of bridge unbalance is automatically detected.

Instrument can be used in wind tunnels, structural test labs, aircraft and missile test stands and production departments.

Datran Electronics

Circle 163 on postcard for more data

NEW MISSILE CHUCK

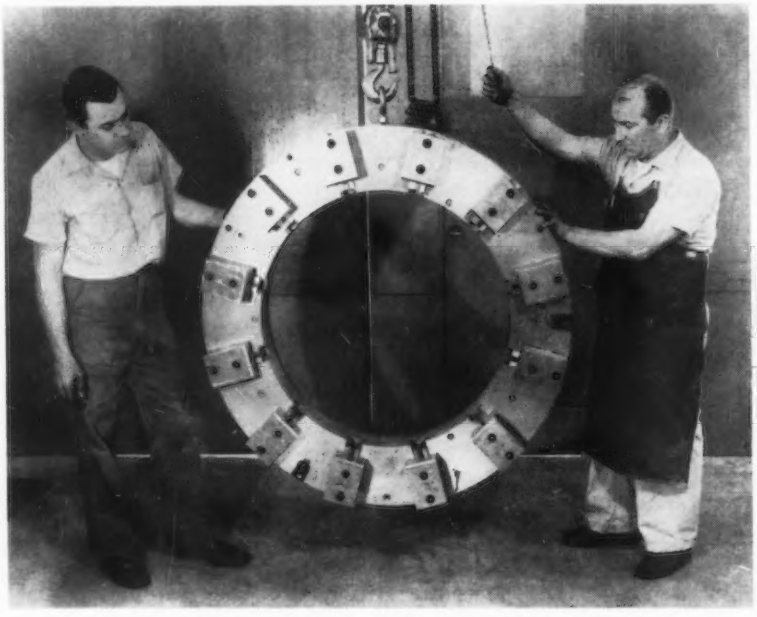
A new 12 jaw universal pinch type chuck holds large diameter missile parts.

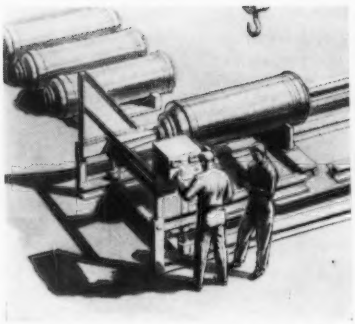
Chuck has 46 in. diam and can be used singularly on vertical lathes, or in pairs on horizontal lathes for parts, sub assemblies, and complete missile tank assemblies.

The concentric expanding and contracting action of the 12 equally spaced universal jaws is used to advantage for rounding out and holding the thin walled sheet metal missile tanks and parts. It is also used for trimming, facing, turning and welding operations.

Horton Chuck Div.
United Greenfield Corp.

Circle 162 on postcard for more data





ROCKET ENGINE WEIGHT

Versatile weight and center of gravity locating device handles a wide range of rocket engine sizes up to a limit of 60 inches in diam by 15 ft in length. No special adjustments are needed for each size.

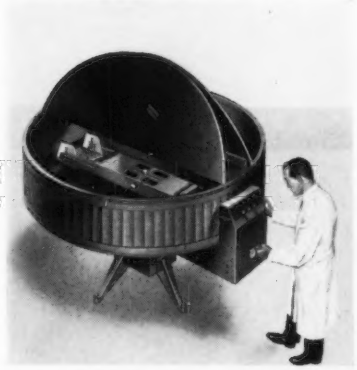
Motors from 200 to 15,000 lb are placed horizontally on two carriages in the bed of the machine. Carriages are then rolled along the bed until a suitable locating point on the engine contacts an adjustable probe on the machine. Weight is read in pounds and c.g. inches from the locating point.

Machine can be used for other devices besides rocket engines. Other models available will handle engines with diameters larger than 60 in.

Hunter Bristol Div.
Thiokol Chemical Corp.

Circle 166 on postcard for more data

CENTRIFUGE LINE HAS UNIQUE DRIVE SYSTEM



New line of centrifuges feature unique, high-torque version of a ball-disc integrator drive system, smoother and more efficient than any now in use.

Constancy of rotation, including low and long term drift, is better than 0.05% at any speed setting—called 10 times better than currently available centrifuges. Speed of the new transmission is infinitely variable from 0 to 800 rpm.

Building block design gives the new centrifuges unusual flexibility. Machines are assembled from six basic, off-the-self components: drive system, motor, test compartment, boom, console, accessories. The customer simply selects the components to meet his specific needs.

Test compartments of extruded interlocking, tongue-and-groove aluminum staves, assembled vertically and held together with hoops.

continued on next page

Symmetrical rotating arms are of welded aluminum construction. Basket-type mounting platforms may be oriented from the horizontal to the vertical or to the inverted attitude.

Genisco Inc.

Circle 161 on postcard for more data

HYDRAULIC ACTUATION IN NEW-SERVO HOIST

A new line of rugged electro-hydraulic servo-hoists utilizes a completely new concept in industrial hydraulics.

The new hoist extends to all industrial lifting operations the speed, controllability, power and safety characteristics of hydraulic actuation.

Designated the AWB Servo-Hoist, the new unit is available in four sizes having nominal capacities of ¼, ½, 1 and 2 tons. Materials can be raised up to 10 ft with any of the four models.

The new servo-hoist design features precision positioning, adjustable-speed action, one-hand operations, and finger-tip control. Its servo control circuit translates hand movements into power boosted motion. It is designed to lift loads at speeds up to three times that of conventional hoists.

Pesco Products Div.
Borg-Warner Corp.

Circle 164 on postcard for more data

LIGHT CAMERA TAKES SUPER-SPEED PHOTOS

High-speed motion-analysis cameras provide photographs at an upper rate of 25,000 16-mm frames per sec. Light, portable, "Dynafax" is arranged for simple, fast film processing, uses standard 35-mm film.

Features include a stable framing rate during the operating cycle which is continually indicated on a built-in meter; absence of synchronizing requirements; exposure times easily adjustable at the maximum rated framing speed of the camera. Total writing time is 9 millisec at 25,000 frames per second.

Requiring no external equipment beyond a common type of variable transformer, Dynafax Camera is 12 inches in diam by 10 inches long and weighs 28 lb.

Beckman & Whitley Inc.

Circle 160 on postcard for more data

NUMERICAL CONTROL TAPE READIED

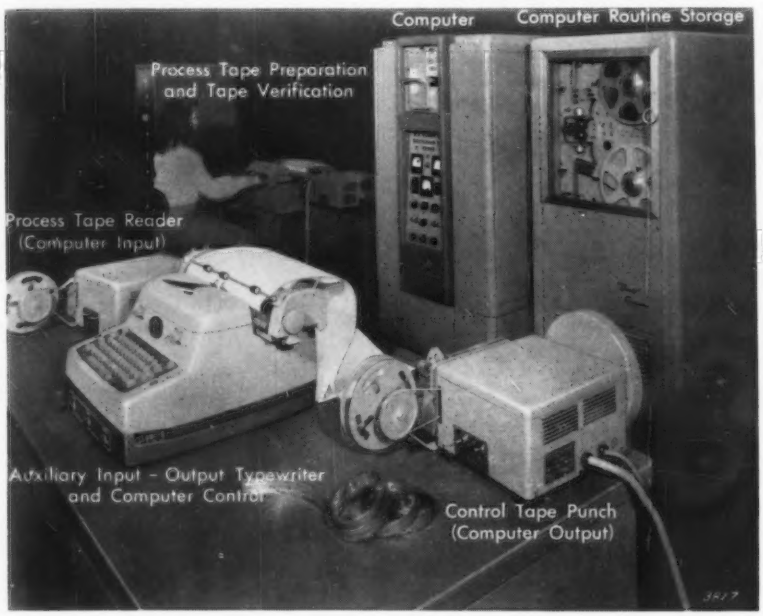
This numerical control tape preparation system will automatically prepare control tapes for two and three-dimensional contour machining of parts composed to straight lines, arcs, circles and free form or point-defined curves.

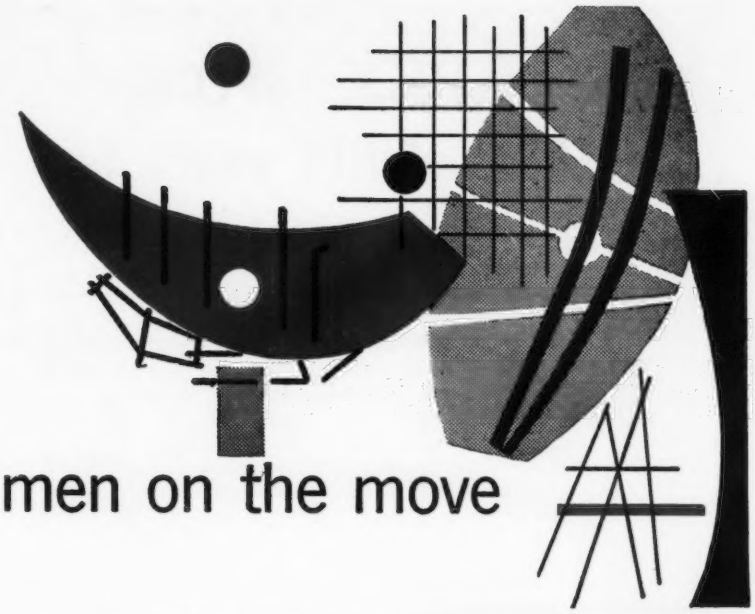
Designated the Compac System (Computer Program for Automatic Control), equipment takes dimensional and machining information from drawings.

Equipment required to produce control tape includes: a prepared form, called a process sheet; a Flexowriter with a tape punch; a Bendix G-15D general purpose digital computer; and a set of computer programs.

Industrial Controls Section
Bendix Aviation Corp.

Circle 165 on postcard for more data


Computer
Computer Routine Storage
Process Tape Preparation and Tape Verification
Process Tape Reader (Computer Input)
Auxiliary Input - Output Typewriter and Computer Control
Control Tape Punch (Computer Output)



men on the move

JAMES N. DAVIS was elected vice president, government operations, Vertol Aircraft Corp.

HAMILTON W. LORD was elected financial vice president in addition to his duties as treasurer.

VIRGIL J. WILTSE becomes vice president-industrial relations.

R. M. OSBORN has been appointed project engineer for Autonetics, a division of North American Aviation, Inc., in the development of the guidance and control system for the Air Force Minuteman I.C.B.M.

HAROLD P. BELCHER was promoted to manager, Quick Reaction laboratory, Avion Div., ACF Industries Inc.

LAWRENCE R. HENDERSHOT was named manager of Special Projects Laboratory.

ERICH M. HELBIG has assumed new duties as Dayton Mgr. for Summers Gyroscope Co.

HARRY H. GOODE was appointed technical director, Systems Div., Bendix Aviation Corp.

G. H. POOL was named national sales manager for closed-circuit television cameras and associated equipment by Electron Corp.

LOUIS B. HABERMAN has been appointed vice president and general manager of Narda Hydraulics Corp., newly formed subsidiary of the Narda Microwave Corp.

CLIFFORD A. SHARPE has been appointed senior vice president of American Bosch Arma Corp.

MAJ. GEN. ARTHUR W. VANAMAN, USAF (RET.) was appointed assistant to the president, Aerojet-General Corp.

WARREN R. SMITH heads the new Applied Science Div. of Fairchild Engine & Airplane Corp.

A. V. ZUKAS has been appointed vice president, Contracts Administration, Parker Aircraft Corp.

ARTHUR W. MILLER has been appointed vice president and general manager of Ultradyne, Inc.

EDWIN A. FINK has been named section manager, Missile Fuze Engineering by Philco Corp's Government & Industrial Div.

E. G. ROWLETT has been made manager of the Los Angeles office, Torrington Co., Bearing Divisions.

CHARLES E. BARTLEY was appointed coordinator, Food Machinery & Chemical Corp.'s activities in the rocket propellant field. Bartley has been president of Grand Central Rocket Co. where he will continue to serve on the board of directors.

DR. CLEDO BRUNETTI has been appointed acting manager and a vice president of Grand Central. He will also continue as an executive director of FMC's Ordnance Div.

DR. DANIEL C. SCHIAVONE has returned to the Rockets Div., Bell Aircraft Corp.

RALPH B. READE has been named manager of the newly-formed Communications Div. of the Airborne Systems Group of Hughes Aircraft Co.

JAMES R. PARR has been appointed vice president and chief engineer of American Industries Co.

CHARLES F. McCABE has been appointed manager of support base activation for Convair (Astronautics) Div., General Dynamics Corp.

DONALD H. STEWART has been appointed representative at Huntsville, Alabama, by Rocketdyne Div., North American Aviation.

MAJ. GEN. GEO. F. SMITH, USAF (RET.) has joined the Magnavox Co. as vice president and general manager of its Government and Industrial Products Div.

ROBERT LENT has been named director of marketing, Statham Instruments, Inc.

continued on next page

Charles E. Bartley
Food Machinery & Chemical Corp.

Dr. Cledo Brunetti
Grand Central Rocket Co.

Ralph B. Reade
Hughes Aircraft Co.

James R. Parr
American Industries Co.

Maj. Gen. George F. Smith
Magnavox

Robert Lent
Statham Instruments Inc.

THESE APEX "SPECIAL" UNIVERSAL JOINTS solved two aircraft design problems

1

JET ENGINE APPLICATION. For precise angular positioning of input and output shafts, circular thread at one end of the joint serves as a worm gear; cap screw in mating part serves as worm.

2

LANDING GEAR APPLICATION. This Apex universal joint acts as a hinge as well as a universal joint. The swing angle on this application ranges from 2° to 56°; the joint itself rotates from 0° to 179°.

Not all Apex aircraft universal joint applications are "specials", but all Apex aircraft universal joints—special or standard—are manufactured to conform to specification MIL-J-6193A.

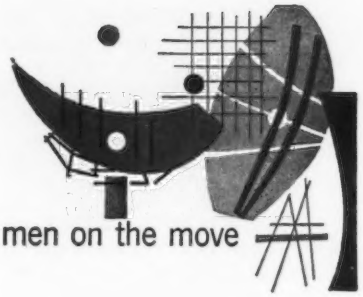
"Standard" or "special", Apex aircraft universal joints offer exclusive design features and operating characteristics that assure a practical, completely satisfactory solution to any design problem involving universal joints.

Only Apex provides joints with sealed, lubricant-retaining covers especially adapted for service in heat, cold, ozone and oil. Covers are also available on the new Apex anti-friction type needle bearing universal joints which are manufactured to conform to Specification MIL-U-3693.

The complete story of Apex aircraft universal joints is included in Catalog 28; write, on your company letterhead please, for your copy.

1933 *A Quarter Century of Service to Industry* **1958**

THE APEX MACHINE & TOOL CO.
1630 South Patterson Blvd.
DAYTON 2, OHIO



CAPT. HAMILTON O. HAUCK joined the Guided Missiles Div., Fairchild Engine & Airplane Corp., last month as director of the Technical Dept.

FREDERICK B. LEE has been appointed director of the Washington office, Olin Mathieson Chemical Corp.

L. BURT AVERY was named vice president and general manager, Sequoia Wire and Cable Co.

E. J. STEPHENS was made general sales manager.

E. J. Stephens
Sequoia Wire and Cable Co.

Robert F. Zumwalt
Firewel Co.

ROBERT F. ZUMWALT is Engineering Manager of the new Space Technology Dept., Firewel Co.

EDWARD V. RYAN is Sales Manager for the Dept.

BENJAMIN S. YAFFE has been named technical service engineer, Defense Products Dept., Callery Chemical Co.

Benjamin S. Yaffe
Callery Chemical Co.

George H. Lieser
Wheelabrator

GEORGE H. LIESER will be field sales manager of the new Techline Div. of Wheelabrator Corp.

FRANK W. SCHREINER has been named district manager of the Cleveland office, Pratt & Whitney Co.

worth asking for:

technical literature listed here is available without charge from the various manufacturers

Data Catalog

Catalog describes thermocouples for nuclear, aircraft, industrial and process fields.

Aero Research Instrument Co.

Circle 185 on postcard for more data

Jet Starting System

Illustrated brochure describes a cold air starting system for jet aircraft.

Wells Industries Corp.

Circle 211 on postcard for more data

Vibration Isolation Systems

Illustrated four-page brochure describes pneumatic vibration isolation systems which protect missile controls, aircraft components, and sled test instrumentation under "g" load changes.

Walter Kidde & Co.

Circle 197 on postcard for more data

Guidance

Specs given on "Invertron" electronic A. C. power source used in research and testing.

Behlman Engineering Co.

Circle 195 on postcard for more data

Vertical Gyro

Bulletin GV-1 covers vertical gyroscope developed especially for aircraft fire control systems.

Electronics Div.
Iron Fireman Mfg. Co.

Circle 196 on postcard for more data

Impact Extrusions

Method of chipless metal forming by Cold Prest impact extrusion process is described.

Mueller Brass Co.

Circle 191 on postcard for more data

Rare and Reactive Metals

Forty-four page handbook presents latest information on rare and reactive metal tubing for application in the chemical, nuclear, and missile fields. Wall chart also available, contains comparative corrosion effects of 44 common corrosive solutions on metals.

Damascus Tube Co.

Circle 200 on postcard for more data

Aircraft Controls

Catalog 53A gives general specifications of firm's automatic valves and switches for aircraft. Includes engineering data on hydraulic fluids; properties of metals and alloys, and atmosphere chart showing air properties at various altitude latitudes.

General Controls Co.

Circle 183 on postcard for more data

Hot Press

"Engineering know-how for Industry" is theme of 16 page brochure with outstanding construction features of hydraulic hot presses and applications in the aircraft, automotive, and other industries.

Berthelsen Engineering Works, Inc.

Circle 203 on postcard for more data

Missile Support

Latest designs in Thor, Snark, and Polaris missile support air conditioning equipment are illustrated and described in a four-page brochure.

C. G. Hokanson Co.

Circle 201 on postcard for more data

Servo System

A completely integrated-electro-hydraulic servo system with unique hydro-mechanical rate feedback network is described.

Hydraulic Research & Mfg. Co.

Circle 208 on postcard for more data

Engineering Aid

A "Servo Calculator" is offered as a plotting tool aid in the solution of network problems in servo analysis.

Magnetic Amplifiers Inc.

Circle 188 on postcard for more data

Forging Materials

A 16-page booklet describes forging materials available for aircraft and missile structural parts, classified for various speed and temperature ranges. Tells metal suitability requirements. Charts compare variations of transverse physical properties of high strength alloy steels.

The Steel Improvement & Forge Co.

Circle 199 on postcard for more data

Tool Sharpening

"How to Ruin a $50,000 Machine," a 32-page illustrated booklet, alerts production superintendents and machine operators against dangers.

The Heald Machine Co

Circle 209 on postcard for more data

Lab Equipment

Revised 1273-page purchasing catalog 400 has over 8,000 listings of laboratory supplies.

The Chemical Rubber Co.

Circle 189 on postcard for more data

Tracer Contouring

Comprehensive booklet on function and performance of air-gage tracer contour system for metalworking operations, including precision turning, facing, and boring work.

The Monarch Machine Tool Co.

Circle 182 on postcard for more data

Barrel Finishing

Compounds designed for deburring, burnishing, and descaling metals in barrel operations are subject of an eight-page booklet. Discusses nature and uses of barrel finishing, methods of cleaning, seluting.

Oakite Products Inc.

Circle 193 on postcard for more data

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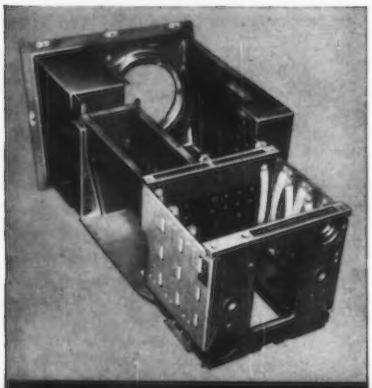
CONVEX? CONCAVE? COMPLEX?



KAMAN CAN BUILD IT

HOUSINGS FOR AIRBORNE ELECTRONICS

Complete manufacturing, processing and inspection facilities housed in 500,000 feet of plant space ideally qualify Kaman to produce housings and chassis for even the most intricate airborne electronic equipment. Kaman's experience in producing parts of magnesium and the other aircraft metals to rigid tolerances and specifications has earned it a part in several missiles and rockets programs. Have you considered Kaman? Write for equipment list and illustrated facilities brochure to J.W. Marshall, Manager.

SUBCONTRACT DIVISION
THE KAMAN AIRCRAFT CORPORATION
BLOOMFIELD 5 CONNECTICUT

Circle 145 on Inquiry Card, page 81

worth asking for:

technical literature listed here is available without charge from the various manufacturers

Design Suggestions

1958-59 pocket booklet gives 53 page outline and check list of factors which should be considered in design to achieve high equipment reliability levels.

U. S. Navy Electronics Laboratory

Circle 187 on postcard for more data

Power Supply

All-transistor power supply, providing 12-volt d-c power for portable, battery-powered test instruments, described in bulletin 7010.

Alectra Div.
Consolidated Electrodynamics Corp.

Circle 202 on postcard for more data

Silicone Fluids

Engineering guide gives properties applications of Silicone Fluids.

Dow Corning Corp.

Circle 210 on postcard for more data

High Pressure Valves

Complete description of Shear-Seal DC solenoid operated valve for pressures up to 3000 psi, with principles of use, standard and explosion-proof applications. Catalog 58-59.

Barksdale Valves

Circle 212 on postcard for more data

Metal Bonding

Booklet describes metal bonding process.

Rohr Aircraft Corp.

Circle 181 on postcard for more data

Aluminum Grommets

Description of aluminum grommeted steel screws and Airloc studs in bulletin.

Monadnock Mills

Circle 194 on postcard for more data

Manufacturing Story

Booklet relates complete operation of the chemical division's operation.

Kaiser Chemical Div.
Kaiser Aluminum & Chemical Corp.

Circle 198 on postcard for more data

Relay

Electronic time delay relay providing instantaneous recycling and delay times from 50 milliseconds to 50 seconds (factory preset) is described in two-page bulletin No. 376-100.

Master Specialties Co.

Circle 206 on postcard for more data

Facilities

Facilities and personnel described in detail in a new 20-page illustrated brochure.

Horkey Moore Associates

Circle 192 on postcard for more data

Data Sheet

Technical data chart describes polyurethane, Thiokol and silicone-based electronic sealants and molding compounds.

Coast Pro-Seal & Mfg. Co.

Circle 186 on postcard for more data

Corporate Story

History, activities of firm serving aircraft, electronics, and missile industries.

Leach Corp.

Circle 184 on postcard for more data

Resistors

"How *Not* To Use Resistors," folder is sequel to earlier folder on transistors.

General Transistor Corp.

Circle 207 on postcard for more data

Titanium Pricing

A pocket-sized four-page bulletin, gives information on titanium pricing.

Titanium Metals Corp. of America

Circle 204 on postcard for more data

This Is Astrodyne

Illustrated brochure shows R & D manufacturing facilities; plus management team of Astrodyne, Inc., jointly owned by North American Aviation, Inc., and Phillips Petroleum Co.

Astrodyne, Inc.

Circle 180 on postcard for more data

Cold Extrusion

Illustrated brochure explains firm's Cold Extrusion Products division, with details on process and equipment.

Cold Extrusion Products Div.
Central Foundry Co.

Circle 190 on postcard for more data

Pump

A four-page illustrated catalog describes operation of variable displacement internal-external pump.

Pesco Products Div.
Borg-Warner Corp.

Circle 205 on postcard for more data

industry notes

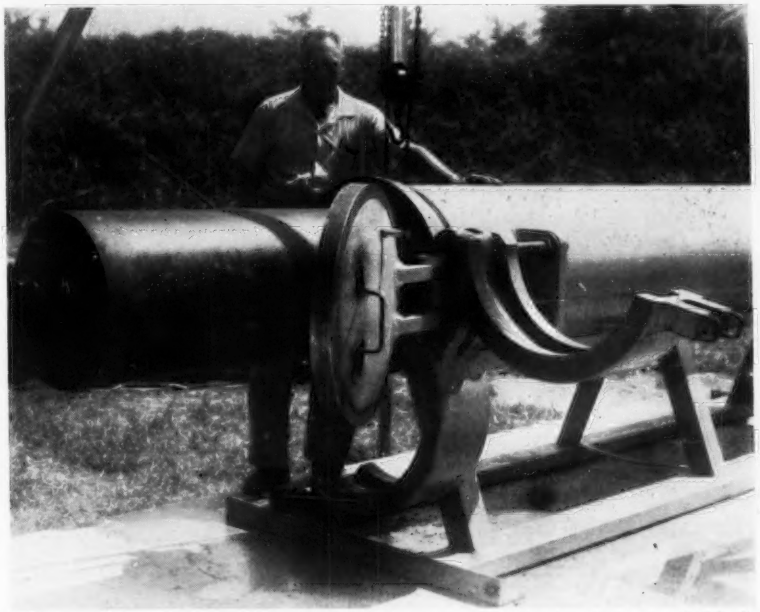
EXPLOSIVE METAL FORMING OF ROCKET CASES

Explosive metal forming —a process frequently used in the fabrication of comparatively small metal parts—can now be used to obtain the precise motion of metal required to achieve tolerances specified in the manufacture of rocket and missile cases.

Application of the metal forming process in the manufacture of 11-ft-long rocket booster cases has been developed by Propellex Chemical Corp., Edwardsville, Ill., a division of Chromalloy Corp.

The basic principle of this process is well-known. The object to be formed, plus an explosive charge, and a shock-transmitting medium are contained within a constraining or retaining die. Force of the explosion is delivered to all parts of the metal piece being formed in a desired distribution pattern.

The specific problem to be solved by Propellex engineers for their customer, Cameron Iron Works, Houston, Tex., was how to straighten 11-ft rocket booster cases and at the same time expand their diameters a predetermined amount.



This seven-ton constraining die straightens and expands diameter of 11 ft rocket booster case by explosive-forming process.

First order of business for Richard P. Gundlach, assistant director of engineering at Propellex, was designing a constraining die. Previous experience with explosive metal forming had demonstrated that the process is adaptable to large metal parts. However, the 11-ft rocket booster case would be the longest piece of metal yet subjected to explosive forming.

A steel cylinder, weighing approximately 14,000 lb., with doors at either end, was designed for the Cameron job.

The explosive charge had to be of a high detonation velocity. Success of this project lay in close quantitative and qualitative control over the charge.

Enclosed in an impermeable covering, the charge is fixed inside the die in a position which will render the precise result in

continued on next page

metal motion which the job requires—straightening the cylindrical case and extending its diameter. (The charge is placed in the constraining die after the rocket booster case has been inserted.)

In any metal forming process, variable spring-back is a problem which must be overcome. The explosive forming process effectively minimizes spring-back, obtaining precise tolerances in one operation. The process also gives increased yield strength of the metal. Propellex estimates the increased yield at 30 per cent.

Rocket and missile shells, fairly symmetrical objects, are obviously well-adapted to explosive forming. However, the process is often adaptable to other, complicated, shapes.

PRIVATELY-OWNED PLANT FOR BERYLLIUM METAL

The nation's first integrated privately-owned plant for fabrication of beryllium metal will concentrate on the nuclear market, with some work on experimental shapes for aircraft research and development.

That's the word at the Beryllium Corp. facility opened this summer near Hazelton, Pa.

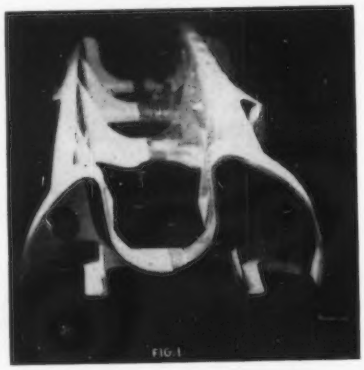
Previously, the only complete beryllium fabricating plant in the U. S. had been owned by the Atomic Energy Commission.

Ingots are lathe chipped into small pieces and ground to a powder. They are then hot pressed under vacuum into shape and machined to various contours. The firm will provide the hot-pressed shapes to other companies interested in fabrication.

CHEMICAL MILLING AND MAG-THORIUM ALLOYS

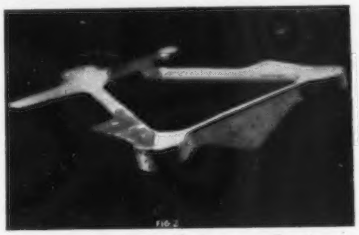
Recent development in the state of the chemical milling art for the Mag-Thorium family of magnesium in sheet, extruded and cast forms simplifies machining processes in the fabrication of aircraft and missile components from these middle range, high temperature resistant metals.

Figure 1 illustrates application of chemical milling to



a structural support for the exterior surface of a control element. In this case the supporting member, magnesium thorium casting, is subject both to transferred heat generated frictionally on the skin surface and to radiated heat.

Figure 2 presents the application of chemical milling to



a contoured and tapered structural member of a wing tip element which is subject both to transferred heat frictionally generated on the skin and to vibrational forces.

Research and development by U. S. Chemical Milling Corp., Manhattan Beach, Calif., resulted in chemical milling methods for the metals which span the gap between the conventional aluminum and magnesium alloys and the heavier steel and titanium alloys

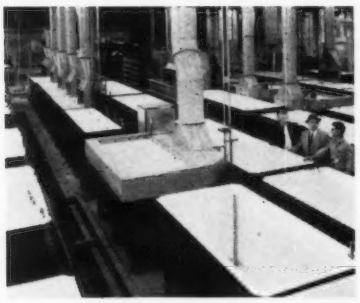
Critical strength temperatures for conventional aluminum and magnesium alloys are in the range of 300 to 350°F, while those of Mag-Thorium alloys are 350 to 500°F.

A 650 lb blade for mixing rocket and missile fuels is shown under arc welding at Baker Perkins Inc., Saginaw, Mich. Low carbon steel axles, shrunk fitted to blade body, are joined to the cast stainless steel mixer blade. Lathe chuck, with variable speed drive, holds and rotates work.

Tubular wall thrust chambers for rocket engines are inspected right on Rocketdyne production line by magnetic particle method. Yoke, formed by powerful Alnico magnets, creates a magnetic field across weld. Hidden fractures cause interruption in this field, attract iron oxide powder, outline irregularity. New procedure is used at Rocketdyne's Slauson facility.

LARGE PLATING PLANT USES SPECIAL PLASTIC

A suit of plastic armor protects the world's largest aircraft plating plant at McClellan Air Force Base, Sacramento, Calif.



Tons of Koroseal polyvinyl chloride material, manufactured by B. F. Goodrich Industrial Products Co., Marietta, Ohio, sheathes equipment at the Air Force plant against corrosive plating solutions and fumes.

The new plant plates and anodizes engine parts, landing gear, tubing, electronic parts, communication equipment, fuel cells and other equipment.

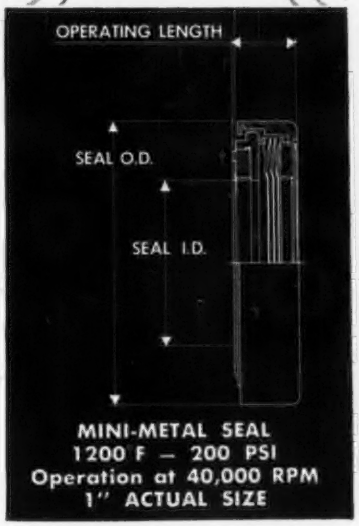
LIGHT JT12 TURBOJET MAY HAVE WIDE USE

The 430 lb Pratt & Whitney JT12 turbojet engine, designed to meet small, high performance requirements, is expected to be in production and available for aircraft within two years.

JT12 is an axial-flow, medium pressure-ratio engine with 2900 lb of static thrust, resulting in high thrust-to-weight ratio of 6.75 to 1. Its engine-plus-fuel weight is rated as exceptionally low.

Fifty-hour endurance test was completed this August, about 13 months after design studies were begun.

NEW!
SEALOL MINI-METAL™ SEAL



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Circle 146 on Inquiry Card, page 81

industry notes

GOODYEAR EXPLORES "CONVOPLANE" CONCEPT

Despite their versatility, helicopters have a weakness: slow forward flight speed.

A new aircraft concept, being explored by Goodyear Aircraft Corp., may result in a transport or reconnaissance craft which could fly forward at high speed besides being able to fly vertically.

In forward flight, air enters the leading edge of the wing, is directed through two large rotors in the combined wing-fuselage area, then leaves via trailing edge. Small vanes aid in changing the direction of flow of air before exit.

Forward flight speed is limited in present helicopters because of compressibility effects at the tips of advancing blades and loss of lift at the inboard part of retreating blades.

For vertical flight, louvers or slates, resembling those used in a venetian blind, would open. Air would flow vertically as in a helicopter.

Contrary to many "converti-plane" plans, the proposed craft would change from forward flight to hovering without the plane or the power rotor axis being rotated. No auxiliary propulsive systems would be used.

Goodyear has been conducting wind tunnel tests on the concept, known as "Convoplane," at its facility in Akron, Ohio.

Advantages foreseen besides the speed factor: increased safety because rotor is inside the plane, design allowing a glide-landing if power fails.

This aerodynamic study is under contract with the Army Transportation Research and Engineering Command, Fort Eustis, Va.

"ALLOY X" RETORTS FOR HONEYCOMB BRAZING

Joining a thin inner core of honeycomb to outer facing sheets is an important operation in manufacture of the latest jet aircraft.

The operation takes place during the brazing cycle in

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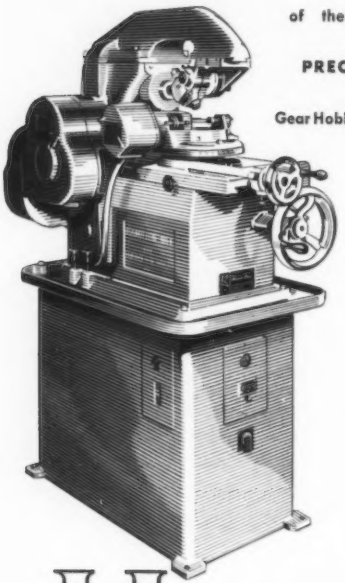

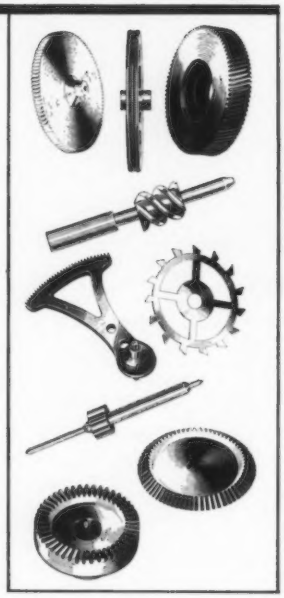

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which temperatures reach almost 2000°F. Most metals are past their melting point at this point — hence special material must be used throughout.

The Alloy Engineering Co., Berea, O., has manufactured large furnace retorts which, placed inside an airframe manufacturer's standard furnaces, provide a "controlled atmosphere" chamber for the brazing.

Retorts are of 3/16-in. sheet "Hastelloy" alloy X, a nickel base alloy which possesses high temperature strength.

In illustration, a welding operator works on retort before shipment to airframe plant.

JET POWER STEALS SHOW AT NBAA MEET

General Aviation (non-military, non-commercial), descended on Philadelphia to show the country its wares during the 11th Annual Meeting of the National Business Aircraft Association, Sept. 22 to 24.

Republic had on display the small, five-place Alouette. Earlier in the week, Republic's Djinn (franchise from Sud) made a fueling stop at Philadelphia.

Vertol showed its twin-turbine (T-53's) Model 107 armed at a large segment of the military and commercial market.

Low-level passes by Fairchild F-27, Lockheed JetStar, Grumman Gulfstream, and Beech MS 760 Paris were the attention getters among the fixed wing aircraft. Lockheed, Grumman, and Fairchild revealed that they have 112 orders among them for their jet executive aircraft. Beech's 760 was an outstanding showpiece.

The smaller, prop-driven aircraft on display will, however, account for the larger sales volume during 1959. General Aviation looks for a record sales year.

Rear view of Chance Vought's F7U-3 Cutlass, one of the early beneficiaries of firm's program for exact training.

HIGH PRECISION AIRCRAFT MANUFACTURE INCREASES UTILITY OF TRAINING PROGRAMS

In 1919, when flight was in its infancy, building a plane was something like fashioning one of today's stockcars. A fairly small crew of careful, skilled craftsmen could do most of the job.

Today, with aircraft and missile work going full blast, the production job is changed tremendously.

An aircraft firm must also function as a school, training technicians in every field of complex manufacture.

Chance Vought Aircraft is a case in point. Because of a growing shortage of competent craftsmen, the firm stepped up its training procedures, inaugurating an apprentice training program in August 1957.

Before set-up was established, standards, registered with the U. S. Dept. of Labor, Bureau of Apprenticeship and Training, were jointly approved by Chance Vought and the local union. A Joint Apprenticeship Committee, composed of two representatives from management and two from the union, was established to administer the program.

Applicants for apprenticeship (over 100 applied the first year) must be between 18 and 24, possessing a high school education or equivalent. Term of apprenticeship is four years with a six month probationary period. Apprentice also takes in-plant related training on company time, and one vocational or college level class related to his trade each year.

Chance Vought foots the

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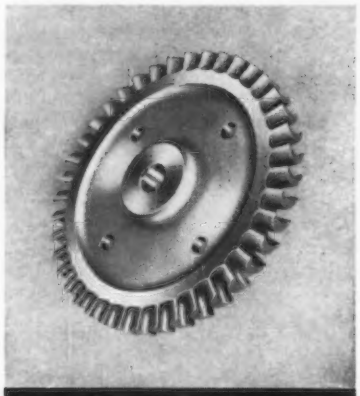

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• blades
• buckets

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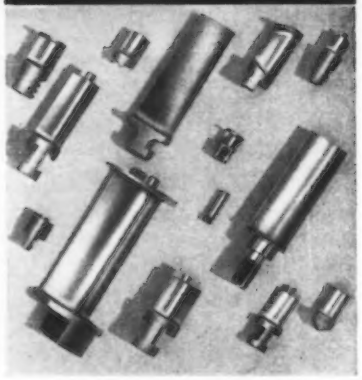

The Schellens-True organization is devoted exclusively to the manufacture of turbine blades, wheels, vanes and nozzles of all types, machined from a wide variety of alloys and materials. We have developed entirely special automatic blade and wheel machining equipment available nowhere else. Creative engineering, precision manufacturing and rigid quality control assure a reliable product at a minimum cost.

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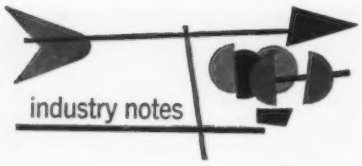


bill on courses, pays the apprentice 60 per cent of the minimum rate of journeymen during the first 1,000 hours; 92 per cent during the last 1,000 hours.

During the year ending this August, eight employees entered the program, six as tool and die makers and two as jig builders. Because the value was found "far greater than was anticipated," entire program will be expanded. (Standards provide that the number of apprentices in any craft can reach 20 per cent of the total of all employees in the craft.)

Another aspect of training: A training department with staff of 26 encourages acquisition of skills, prepares report forms, writes text books where practical manuals aren't available.

In this and other aircraft plants, learning the company and the job also goes far beyond apprenticeship. Other training includes pre-assignment or shop training, in-plant supplementary, pre-assignment, technical supplementary, and supervisory. Some 900 persons participate in supervisory program.

Entire program, when it includes company-sponsored schooling, management development, training for special projects, is massive. However, a modern aircraft firm is used to bigness. Many at Chance Vought, for instance, remember the big move of 1948, when the firm, then a division of United Aircraft, was selected by the Navy to occupy the Naval Industrial Research Aircraft Plant in Dallas. Vought shifted 27 million lb. of machinery and equipment in 1,001 freight cars from Stratford, Conn. Some 1,300 employees and their families also made the move.

FRAMING A FLAME

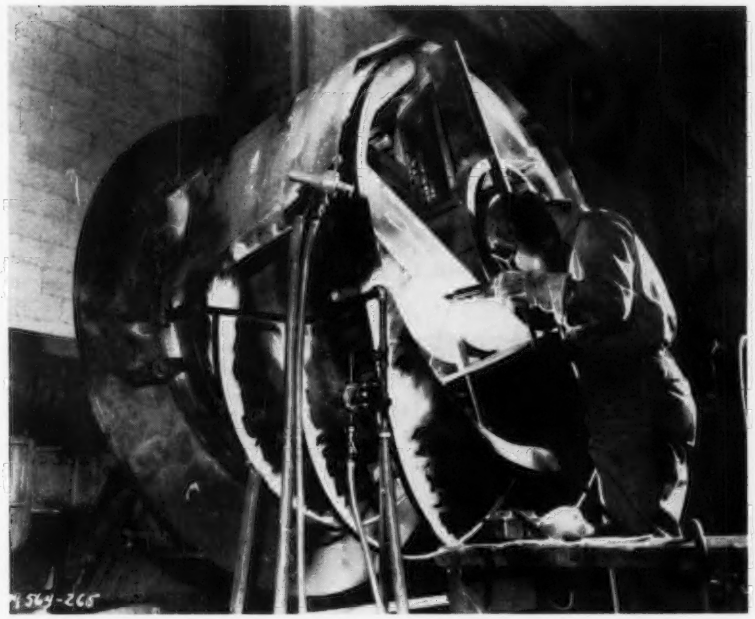
The roaring fire inside the tailcone of jet engines is "framed" in position by a Heliarc welded flame gutter. The gutter actually "catches" the jet-engine flame, creating a turbulence in the flow of hot gases through the aft section of the engine, which causes the flame to cling to the gutter assembly. This prevents "flame-cuts" and thus increases available thrust.

Flame-gutter assemblies are made from bar stock, small forgings, and 0.030 to ⅛ in. thick sheets of Multimet alloy. The inner and outer sections of the assembly are joined by Heliarc welding. A Heliarc HW-9 torch is used with Hastelloy W filler rod. After heat treating and machining, the 36-in. diam, 38-lb "frame" is ready for installation.

Heliarc welds remain sound up to 1800 F.

Flame gutter assemblies are fabricated by Twigg Industries, Ind.

The "Bomarc Bronco," developed by Boeing Airplane Co., tests guidance system of IM-99 missile. Device puts missile through a 2½ minute simulated flight sequence to check out automatic pilot. Tester also functions as assembly vehicle; missile rides it through inspection and testing.



Chrome-moly steel gas turbine cylinders were kept at 450° F during welding operation at R. C. Mahon Co., Detroit. Cylinders, 4850 lb each, were mounted on rotating tables. Heat protected against stress cracks as center hubs were welded on.

DATA-HUNTING TROUBLES SOLVED

A staggering number of man hours is lost each year in the U. S. because of time-consuming searches for needed technical data.

A first step in automatic "information retrieval" has been made at the library of General Electric's Aircraft Gas Turbine Div., Cincinnati, O. A series of magnetic tapes hold concise abstracts of each document, plus descriptive key words and document file numbers.

Tapes are used with IBM 704 computing equipment located in the same building.

The division has recorded over 30,000 document abstracts on only three tapes, and can accommodate about one million. A "literature search," which used to take 14 hours, now is reduced to less than 15 minutes.

SABRELINER WILL PARE COSTS

North American's small new twin-jet utility trainer, the "Sabreliner," marks the arrival of jet-powered small and medium sized aircraft.

The highly-maneuverable plane made its first flight late in September. It can cruise at 500 mph and carry 10 people across the continent with only one stop for refueling.

Smaller than the F-100 Super Sabre and weighing only 15,330 lb, Sabreliner is also designed to support military operations by transporting high priority spare parts or key maintenance personnel for grounded combat aircraft.

The hour-long first flight, which reached 35,000 ft., was powered by General Electric's new lightweight J85 turbojet engine (2,000 lb thrust). This engine is designed for both piloted and pilotless applications. The missile version was qualified for production after passing 15 hour preliminary flight testing earlier this year. It is also being used in McDonnell Green Quail decoy missile and the Northrop T-38 jet trainer.

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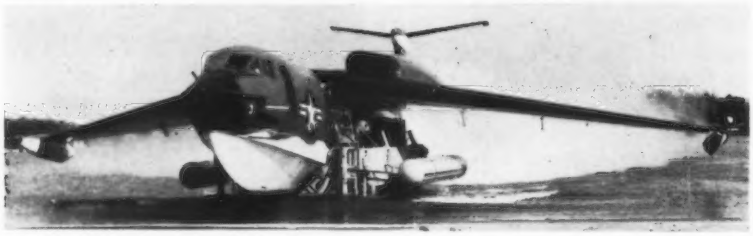
industry notes

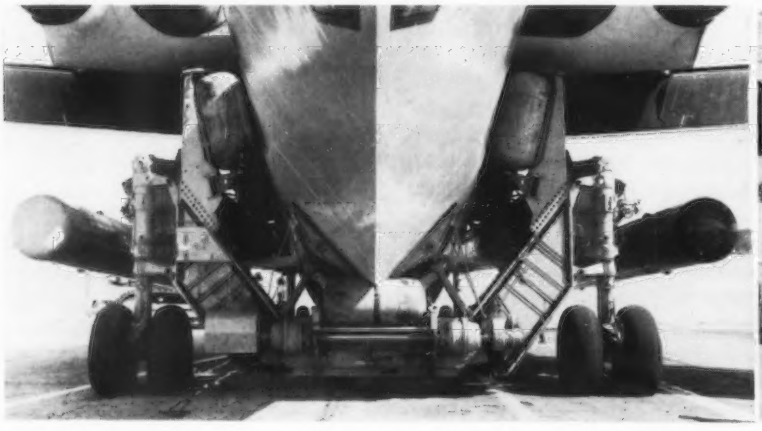
bringing the SeaMaster home

SeaMaster approaches beaching vehicle near Martin's Baltimore seadrome. Circular pressure pads, hydraulically operated, stand ready to grasp sides of hull. P6M has 600 mph speed; unrefueled range of 1,500 mi with 16 ton payload.



Mated with vehicle, seaplane emerges from water on concrete pavement. Her four Allison J71 turbojets provide power for entire landing operation. Steering and braking mechanism of vehicle is controlled by pilot.

Rear view of seaplane landing mechanism. Aircraft is one of six evaluation P6M's. Martin is building 24 SeaMasters for the Navy. They are intended for minelaying and reconnaissance.



Self-beaching aircraft can maneuver on land with freedom of land planes. Wheel tracks on concrete show path after leaving water. First Navy inspection trials are set for next Spring.

New beaching vehicles facilitate beaching and ground handling of the Navy's big new P6M SeaMaster.

Formerly, the P6M, like other large seaplanes, used attachable wheels when entering or leaving the water. On land, it was maneuvered with the aid of tractors and a crew of half a dozen or more attendants.

Now, the P6M's use a beaching vehicle, moored in the water unattended while the planes are flying, and mated to the aircraft before it leaves the water. Hydraulically - operated pressure pads grasp the sides of the seaplane when it taxies into the vehicle in the water. The plane's four jet engines provide the sole power to taxi out the water onto the concrete ramp and to a parking place.

Officials at the Martin Co., said the vehicle's steering and braking mechanisms are controlled by the pilot. Martin is building twenty - four SeaMasters for the Navy.

First model of beaching equipment was built for Martin by Aeronca Manufacturing Co., Middletown, O. Aeronca also supplied Martin with tooling for future production of the gear.

IMPRINT OF SPACE AGE ON INDUSTRY DISCUSSED

Here are some of the highlights of the forum on impact of space flight on industry, held in conjunction with the Fall meeting of the American Rocket Society in Detroit.

The new National Aeronautics and Space Agency reflects trend towards centralized research and development, according to Dr. George E. Valley, Jr., Air Force Chief Scientist. Valley predicted that industry would only be called upon to build a few special space vehicles by itself. Rather, he said, future projects would see industry teaming up with basic research groups such as those in universities.

K. J. Bossart, Convair-Astronautics, declared that space travel will lead to expansion of design offices and test labs at the expense of manufacturing facilities. He said also that capital expenditures would grow out of proportion to manufacturing costs.

W. H. Henley, Marquandt Aircraft, said hydraulic-pneumatic controls were favored for ramjet engines instead of electronic controls because of their reliability.

John S. Sheldon, Chrysler Missile Div., said many new welding problems were encountered at start of the Jupiter program because of the high strength aluminum alloys needed for the ballistic shell. All welding operators, for instance, had to be requalified to a new, stringent government specification.

Lt. Col. Frank E. Napper of Redstone Arsenal scored unnecessary duplication of common instruments. He declared that electronic test equipment now in the field has been designed specifically for one system and is packaged for that system alone. He then proposed a universal package designed to test functions rather than any given chassis.

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Classified Advertisement

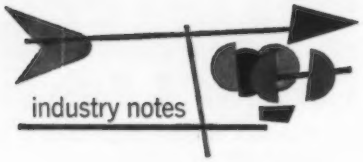
Helicopter patent, new propulsion design, high efficiency, commercial, military. For development, sale. Box 6, Aircraft and Missiles Manufacturing, Chestnut and 56th Sts., Philadelphia 39, Pa.

ROCKETDYNE AWARDED NEW ARMY CONTRACT

The Army has awarded Rocketdyne Div. of North American Aviation a new contract for propulsion units going into a 1,500,000-lb-thrust booster vehicle.

The contract for the units—currently tested rocket motors from Thor and Jupiter systems—resulted from need for a quick and relatively inexpensive means of obtaining a system capable of placing very large payloads into orbit.

Motors will be repackaged into a single unit. Work is taking place at Rocketdyne's main plant in Canoga Park, Calif.



INDUSTRY STATISTICS

Source: Bureau of the Census and Civil Aeronautics Administration.

NUMBER AND VALUE OF CIVIL AIRCRAFT SHIPMENTS

Month	Units		Value in Thousands	
	1958	1957	1958	1957
January	579	584	$ 62,311	$ 48,431
February	510	523	65,046	49,278
March	697	675	35,133	46,636
April	704	657	47,496	57,980
May	622	672	35,113	84,136
June	589	590	25,455	69,497
July	503	525	41,587	70,649
August	471	519	30,776	62,990
September		466		54,911
October		474		45,687
November		516		47,213
December		544		44,856
Total—Year		6,745		$682,264
Total—8 Mos.	4,675	4,745	$342,917	$489,597

AIRFRAME WEIGHTS OF CIVIL AIRCRAFT SHIPMENTS

Month	Thousands of lbs.		Avg./Aircraft	
	1958	1957	1958	1957
January	1,909.9	1,574.9	3,299	2,697
February	1,891.4	1,554.0	3,709	2,971
March	1,313.2	1,625.6	1,884	2,408
April	1,606.4	1,886.6	2,282	2,871
May	1,293.4	2,558.0	2,079	3,806
June	1,068.1	2,114.0	1,813	3,583
July	1,418.7	2,096.0	2,820	3,992
August	1,106.5	1,950.6	2,349	3,758
September		1,641.1		3,522
October		1,456.5		3,073
November		1,480.8		2,870
December		1,430.8		2,630
Total—Year		21,368.9		3,168
Total—8 Mos.	11,607.6	15,359.7	2,483	3,237

SHIPMENTS OF PISTON ENGINES FOR CIVILIAN AIRCRAFT

Month	Units		Value	
	1958	1957	1958	1957
January	1,033	920	$ 8,883,000	$ 12,445,000
February	1,139	902	9,696,000	13,596,000
March	994	1,010	8,174,000	13,975,000
April	881	950	8,174,000	14,388,000
May	828	1,020	6,176,000	15,160,000
June	783	933	5,994,000	15,636,000
July	730	801	4,898,000	12,748,000
August	693	776	3,420,000	8,603,000
September		728		10,150,000
October		921		13,638,000
November		878		9,880,000
December		1,020		12,237,000
Total—Year		10,859		$152,456,000
Total—8 Mos.	7,081	7,312	$ 55,415,000	$106,551,000

TOTAL HP. OF AIRCRAFT PISTON ENGINE SHIPMENTS FOR CIVILIAN USE

Month	Total Hp. (in Thousands)		Avg. Hp. per Engine	
	1958	1957	1958	1957
January	459.9	604.4	445	657
February	518.2	647.0	455	717
March	440.7	679.2	443	672
April	428.0	668.2	486	703
May	338.3	715.8	409	702
June	328.7	730.4	420	783
July	282.1	590.4	386	737
August	210.0	425.6	303	548
September		482.8		663
October		628.3		661
November		473.0		539
December		586.2		575
Total—Year		7,231.3		666
Total—8 Mos.	3,005.9	5,061.0	424	692

VALUE OF SHIPMENTS OF AIRCRAFT PROPELLERS AND PARTS

All data are in Thousands of Dollars

Period	Total All Products	For Military Aircraft	For Civilian Aircraft	Other Products†
1958				
First Quarter	$ 65,500	$ 38,983	$ 9,503	$ 17,014
Second Quarter	68,101	36,564	9,296	22,241
Total—Six Months	$133,601	$ 75,547	$ 18,799	$ 39,255
1957				
First Quarter	$ 51,079	$ 20,767	$ 11,599	$ 18,713
Second Quarter	60,772	27,065	11,483	22,224
Total—Six Months	$111,851	$ 47,832	$ 23,082	$ 40,937
Third Quarter	66,194	31,658	7,836	26,700
Fourth Quarter	72,140	41,117	10,800	20,223
Total—Year 1957	$250,185	$120,607	$ 41,718	$ 87,860

† Includes experimental work.

SHIPMENTS OF PROPELLERS FOR CIVILIAN AIRCRAFT

Month	Number of Propellers	
	1958	1957
January	1,132	1,148
February	1,186	1,403
March	1,202	1,629
April	1,358	1,475
May	1,299	1,572
June	1,307	1,419
July		1,120
August		1,192
September		1,152
October		1,338
November		1,372
December		1,194
Total—Year		16,014
Total—Six Months	7,484	8,646

TERRA-SCOPE

Four new "superconductors" have been discovered by physicists of Westinghouse Research Laboratories. They are among the intermetallic compounds containing uranium and cobalt, manganese and iron. Discovery came during work on electrical resistance of uranium alloys at very low temperatures.

•

A new radar set does away with need for light-proof hoods during daylight. Designed and produced by Bendix-Pacific Div. of Bendix Aviation, cooperating with Wright Air Development Center, radar indicator gives sharp images in strong sunlight.

•

Prime contractor for Minuteman ICBM is expected to be announced this month or early next month.

•

Test firing of Polaris missile from "ship motion simulator" on the ground is scheduled this month at Lockheed Aircraft's Sunnyvale, Calif., plant. Simulator, 40 ft high and 285,000 lb, reproduces ship motions up to a class 5 storm. Prime contractor: Loewy Hydropress Div. of Baldwin-Lima-Hamilton Corp. Firings will test guidance system.

•

X-15 tests through the Summer of next year are mostly planned as "preliminary" ones; standard test piloting of handling characteristics and the "design envelope" at comparatively low levels. Reportedly, few changes have been made in X-15 since July. In centrifuge tests, "involuntary pilot inputs" on control instruments due to the stresses of high flight were not found prohibitive.

•

Important instrument of X-15 somersaults: two gimbal attitude indicators. In front of pilot's head, it is a sphere which rotates with turns so he can see cardinal points of compass. The instrument shows black if nose is down, white if it is up.

The Navy has awarded a contract of over $10-million to Lockheed Aircraft Corp. for preproduction engineering work on the P3V-1 Electra anti-submarine warfare patrol plane. . . The Air Force awarded Kaman Aircraft $10,000,000 "follow-on" contract for 54 of its H-43B local, air base, crash-rescue helicopters. . . Swissair and SAS airlines have placed an initial order for five intercontinental 880 jet transports with Convair Div., General Dynamics Corp. Delivery is set for the Fall of 1960.

•

Decision to stop full-scale production of either Air Force Thor or Army Jupiter IRBM comes this month from Secretary of Defense McElroy. Thor has been widely predicted as the winner. Loser would still be used as specialized research vehicle and limited production would probably continue a while. Thor represents design and manufacture by private industry. Jupiter was developed under Army's arsenal system.

•

"Hyperthermal" wind tunnel test facility, produced by the Giannini Plasmadyne Corp., maintains elevated temperatures corresponding to 23,000 ft/sec for extended periods of time. Facility uses a plasma jet device as flow source and a continuous arc tunnel.

•

Air Force Association, at its annual convention in Dallas, unanimously passed statement calling for consolidation of Army, Navy, and Air Force into a single department.

•

"A-916-B," a new family of rubber-like adhesives, developed at B. F. Goodrich's Brecksville, O., research center, shows ability to bond many previously incompatible surfaces.

General Electric's Missile and Ordnance Systems Dept., Phila., has been re-established as the Missile and Space Vehicle Dept., focusing on advanced projects. The Ordnance Dept., Pittsfield, Mass., becomes a separate operating component of Defense Electronics Div.

•

Advent of commercial jets finds Weather Bureau pushing modernization of airport weather devices and expanding flight forecasting capabilities. Under development is scanning device—based on infrared principle—to automatically give "sky cover" around a terminal.

•

Expanded flight evaluation would include upper air soundings from 108 stations four times a day; continuous wind sounding to 100,000 ft; basic computer analysis of weather up to 45,000 ft. Plans envisage radar system weather surveillance covering every airport. Forecasting would be only five minutes in advance of pilot.

•

The Army is reported still seeking a completely satisfactory anti-tank missile. Contract for development of Dart solid propellant missile has been cancelled.

•

New infrared fire control device, developed by Avionics Div., Aerojet-General Corp. working with Lockheed Aircraft, is being installed on F-104 Starfighter. It senses position of aircraft at night, is operational at high altitudes.

•

Chrysler Corp. has received an extension of its Redstone production contract. The new money amounts to $27-million.

•

Republic Aviation Corp. has awarded Beech Aircraft a military production contract in excess of $6-million for aft fuselage sections and ailerons for the F-105 "Thunderchief."

november 6-7
symposium on applied spectroscopy
hotel new yorker, n.y., n.y.

◆

november 6-7
national specialist meeting on dynamics and aeroelasticity
institute of the aeronautical sciences, texas section,
fort worth, texas

◆

november 10-12
international conference on physics and medicine of the atmosphere and space
school of aviation medicine
san antonio, texas

november 11-14
annual convention
national trades assn.
milwaukee, wisc.

◆

november 12-14
aircraft hydraulics conference
vickers inc.
park shelton hotel, detroit, mich.

◆

november 12-14
annual meeting
society for experimental stress analysis
albany, n. y.

november 16-21
conference on scientific information
air force office of scientific research, NAS, NFS and american documentation institute
mayflower hotel, washington, d. c.

◆

november 17-18
aircraft and missile division conference
american society for quality control
biltmore hotel, dayton, o.

◆

november 17-21
annual meeting and astronautical exposition
american rocket society
hotel statler, n. y., n. y.

◆

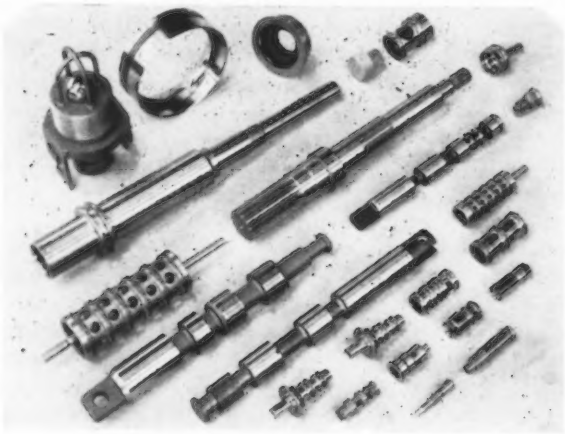
november 18-20
national conference on standards
hotel roosevelt, n. y., n. y.

◆

november 19-21
32nd meeting
aviation distributors and manufacturers assn.
dallas, tex.

◆

november 28-december 4
electronic computer exhibition and symposium
olympia,, london, eng.



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161 **Centrifuges**
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162 **Chuck, missile**
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United Greenfield Corp.

163 **Gages, strain**
Datron Electronics

164 **Servo-hoists**
Pesco Products Div.
Borg-Warner Corp.

165 **Tape, control**
Industrial Controls Section
Bendix Aviation Corp.

166 **Weigher, rocket engine**
Hunter Bristol Div.
Thiokol Chemical Corp.

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169 **Connectors, rack-panel**
The Deutsch Co.

170 **Control, electro hydraulic**
Garrett Corp.

171 **Drill Bushings**
American Drill Bushing Co.

172 **Dryer, instrument**
Daco Instrument Co.

173 **Fiber, asbestos**
The Zippertubing Co.

174 **Filter, radar**
Airtron Inc.

175 **Regulator, pneumatic**
Wallace O. Leonard Inc.

176 **Speed Changer**
Metron Inst. Co.

177 **Switch, pressure**
Frebank Co.

178 **Transducer, diaphragm**
Ultradyne Inc.

179 **Transducers, temp.**
Arnoux Corp.

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Coast Pro-Seal & Manufacturing Co.

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Magnetic Amplifiers Inc.

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The Chemical Rubber Co.

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Central Foundry Co.

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Horkey Moore Associates

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Oakite Products Inc.

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Monadnock Mills

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Behlman Engineering Co.

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Electronics Div.
Iron Fireman Mfg. Co.

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Walter Kidde & Co.

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Berthelsen Engineering Works Inc.

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Titanium Metals Corp. of America

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Pesco Products Div.
Borg-Warner Corp.

206 **Relay**
Master Specialty Co.

207 **Resistors**
General Transistor Corp.

208 **Servo System**
Hydraulic Research & Mfg. Co.

209 **Sharpening, tool**
The Heald Machine Co.

210 **Silicone Fluids**
Dow Corning Corp.

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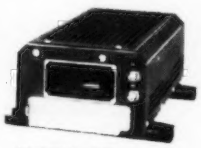

SELENIUM UNIT
Model 28V50C

CHATHAM ELECTRONICS
division of
TUNG-SOL ELECTRIC INC.

CHATHAM... *world's leading supplier of airborne conversion equipment.*

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51% More Production

when drilled with the

BENCH MODEL BURGMASTER
Turret Drilling Machine

JOB DATA:

Part: Gas furnace pilot burner head.

Location: General Controls Co., Glendale, Calif.

Material: Type 2202 stainless steel.

Operation: Drill 10 holes No. 56 drill size.
Drill 1 hole No. 42 drill size.
Drill 1 hole No. 37 drill size.

All hole positions indexed radially around jet axis. Turret is double tooled.

Former Method: Production—58 pieces per hour, standard, on a 3 spindle gang drill. Fixture was progressively moved from one spindle to the next on 8' table.

Burgmaster: Production—88 pieces per hour, standard, with actual production running 130% over standard. Operator fatigue greatly reduced. All holes now drilled from one operator position on a stationary rotating fixture. Floor area requirements per machine reduced 50%. Based on savings alone this machine paid for itself in less than 5 weeks!

Paid for itself out of savings in less than 5 weeks!

THE BURGMASTER TURRET DRILLING MACHINE speeds all second operations—*center drills, drills, reams, taps, spot-faces, countersinks,* and *counterbores!*

SELF-INDEXING—Turret instantly power-indexes to successive station after each individual operation is completed!

6 STATIONS—Only one live spindle! Each spindle operates at its own predetermined speed. Two complete ranges cover 350 to 6200 rpm.

¼" CAPACITY IN STEEL—Larger hole sizes in softer materials.

For *more* parts per hour, for *lower* costs, put your second operations on a BENCH MODEL BURGMASTER TURRET DRILLING MACHINE! Here's a tool that not only produces more parts faster... it costs *far less* than conventional equipment often used for the same job! Write for circulars and specifications!

BURGMASTER BENCH MODEL 6 SPINDLE AUTO INDEXING TURRET DRILL & TAP MACHINE

Want to see the Burgmaster in action? We'll arrange a free demonstration in your plant upon request!

BURGMASTER CORPORATION

Small Tool Division • Burg Tool Manufacturing Co., Inc.

13226 S. Figueroa St., Box 311, Gardena, Calif. • Phone: FAculty 1-3510

phone, wire or write Dept. A-11

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